THE SEMICONDUCTOR DATA LIBRARY



MOTOROLA Semiconductor Products Inc.

SECOND EDITION - VOLUME II

TYPE NUMBERS 1N5000, 2N5000 AND UP
PLUS NON-REGISTERED TYPES

THE SEMICONDUCTOR DATA LIBRARY

SECOND EDITION
VOLUME II

prepared by
Technical Information Center

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THE SEMICONDUCTOR DATA LIBRARY

One of the major problems facing workers in the electronics field is the identification and selection of semiconductor devices. Type numbers assigned to the semiconductors are of little value since they indicate neither device parameters nor applications. Because it is difficult even to identify the many thousands of device type numbers, let alone evaluate their merits for a particular application, engineers often limit their designs to a few well-known device types — despite the fact that newer or more suitable devices may be available. To help alleviate this problem, the Motorola Semiconductor Data Library has been developed.

The Motorola Semiconductor Data Library identifies and characterizes all semiconductor devices with 1N---,2N---,3N---, and 4N--- numbers registered with the Electronics Industries Association at the time the library was printed, as well as a broad line of devices with special in-house type numbers. (It provides complete data sheet specifications for a wide range of discrete semiconductors, and short-form specifications for integrated circuits.) And in addition, to simplify the selection of the most useful semiconductor type numbers, it contains carefully prepared selector guides with recommended devices for specific applications. Properly used, it can be a valuable aid for the design engineer, the component engineer, and the purchasing agent in narrowing the broad categories of potentially usable components to those best suited for a specific project.

COMPOSITION OF THE LIBRARY

The Semiconductor Data Library is divided into three volumes, organized as follows:

REFERENCE VOLUME

The reference volume is a self-contained compendium of semiconductor devices and integrated circuits information. This volume enables the user to locate and select devices for most any application or specific circuit. It also contains package and hardware information as well as applications information. Once a preliminary selection of a potentially suitable device has been made, consult Volumes I or II for detailed specifications for that particular device.

EIA Registered Device Index — Complete numerical index of all EIA registered device types, with major electrical specifications.

Non-Registered Device Index — Complete numerical index of all in-house non-registered Motorola device types, with major electrical specifications.

Master Selection Guides — Grouping of preferred devices by major device categories for quick preselection of devices best suited for specific applications. Includes semiconductor devices and ICs.

Military Device Listing — A complete list of Motorola devices that comply with Military Specifications.

Hardware and Packaging Information — Device mounting hardware, heat sinks and special device packaging.

Dimensioned Device Outlines — Dimensioned drawings of package outlines with JEDEC and Motorola cross reference. (Includes leadform drawings on specific packages.)

Application Note Catalog — Selection guide listing application note by application category. Also a brief summary of the available application note contents and how to order application notes.

To meet the requirements of a practical up-to-date reference, the Reference Volume of the Semiconductor Library will be completely updated and published twice a year.

VOLUME I

This volume contains complete data sheets for Motorola-manufactured devices with EIA-registered type numbers up to 1N4999 and 2N4999. Data sheets are in numerical sequence according to device type number except for those data sheets that cover several devices with differing type numbers. A numerical index in front of the book permits the user to quickly locate the page number of the data sheet for any device characterized in the book.

Since most of the device type numbers in the "below 5000" category have already been utilized by existing product, it is expected that this book will require little updating in the next few years. Accordingly, this volume will be reprinted only as required by the demand, and modifications will be made only when reprinting is required.

VOLUME II

This volume contains data sheets for all Motorola-manufactured, EIA registered devices with type numbers 1N5000 and 2N5000 and up, as well as those with 3N- - - type numbers. In addition, all active data sheets for devices with special Motorola type numbers (not registered with EIA) are included.

Because this book contains the detailed data for all the most recently developed semiconductors, it will be updated through the publication of supplements.

How to Use The Semiconductor Data Library

The library is designed to serve several specific functions;

1. To permit quick identification (together with major specifications) of EIA registered semiconductor devices with units with special Motorola type numbers.
2. To permit quick selection of the most suitable devices for a specific circuit application.
3. To permit quick selection of the devices that best meet a given set of electrical specifications.
4. To provide complete characterization of a broad line of components, encompassing most semiconductor categories, for a detailed comparison of device types.

The following examples illustrate several ways of using this library.

Problem: Device Identification
Known: Device Type Number
Information Needed: Device function, applications, major specifications.
Procedure: Consult the Master Index of the Reference Volume and locate the type number of the device in question in the alpha-numeric listing of the master index. The information given in this index lists not only the type of device it is, but also provides the major electrical specifications for the device. In addition, it indicates whether or not the device is manufactured by Motorola and, if not, whether Motorola can supply an electrically suitable equivalent. Complete data for Motorola manufactured devices can then be obtained, if required, from the other two volumes of your Semiconductor Data Library.

Problem: Device Preselection
Known: a) Intended circuit application for a particular device
b) Approximate electrical specifications of a desired device.
Information Needed: a) What devices are available for a specific circuit function?
b) What device types will best match a required set of electrical characteristics?

Procedure: Consult the Master Selection Guide section of the Reference Volume. This section contains product categories, i.e., power transistors, zener diodes, etc., and by specific market segments, including communications, consumer and military. An index to the individual selector guides is given at the beginning of the section for quick access to the pertinent guides. Complete data for Motorola manufactured devices can then be obtained, if required, from the other two volumes of your Semiconductor Data Library.

CATALOGUE DE SEMICONDUCTEURS

Identifier et ensuite choisir les dispositifs semiconducteurs constituent l'un des grands problèmes que rencontrent ceux qui travaillent dans le domaine de l électronique. Les différents dispositifs sont désignés par des chiffres ne donnant aucune indication sur leurs paramètres et sur leurs applications. La difficulté pour les techniciens et ingénieurs d'identifier plusieurs milliers de dispositifs les amènent à utiliser, lors de la conception de circuits, des dispositifs bien connus alors que d'autres dispositifs mieux adaptés sont disponibles. Afin de pallier cet inconvénient, Motorola a donc institué ce catalogue de semiconducteurs.

Le Catalogue de Semiconducteurs de Motorola identifie et caractérise les dispositifs semiconducteurs enregistrés auprès de l'Association des Industries Electronqiues (EIA) par les symboles 1N--,2N--,3N-- et 4N-- ainsi que les dispositifs propres à Motorola avec des numéros spéciaux. (Ce catalogue contient les spécifications complètes pour tous les semiconducteurs discrets, et des spécifications abrégées pour les circuits intégrés.) De plus, afin de simplifier le choix des dispositifs les plus utiles, il contient également un "guide" mettant en évidence les dispositifs destinés à des applications bien spécifiques. Son utilisation adéquate peut donc être un outil de travail très utile pour l'ingénieur de circuit, l'ingénieur de composants, et l'acheteur en leur permettant de limiter le nombre de composants possible convenent le mieux pour un projet bien determiné.

INDEX DU CATALOGUE

Le Catalogue de Semiconducteurs comprend trois volumes:

VOLUME DE REFERENCE

Le volume de référence résume les renseignements sur les dispositifs semiconducteurs et circuits intégrés. Ce volume permet donc à l'utilisateur de déterminer et de choisir les dispositifs pour la majorité des applications; il contient également des renseignements sur les boitiers et sur les systèmes de montage. Une fois le choix du dispositif effectué, il suffit de consulter les Volumes I et II pour obtenir toutes les données concernant ce dispositif.

Index des Dispositifs Homologués par EIA

Cet index fournit également les données électriques principales.

Index des Dispositifs Non-Homologués

Cet index fournit une liste complète des dispositifs Motorola non-homologués, avec leurs données électriques principales.

Guide

Les dispositifs les plus utilisés y sont groupés par catégories principales pour un choix rapide des composants les mieux adaptés à certaines applications (y compris dispositifs discrets et circuits intégrés.)

Liste des Dispositifs Militaires

Cette liste fournit tous les dispositifs Motorola homologués par les Spécifications Militaires.

Boitiers et Modes de Montage

Fournit les modes de montage, les radiateurs et les boitiers spéciaux.

Dimension des Boitiers

Dessin et dimension des boitiers homologués par JEDEC et Motorola (y compris les dessins pour former les tiges.)

Catalogue de Notes d'Applications

Fournit une liste complète des notes d'applications groupées par catégories, également un résumé des notes d'applications disponibles et la marche à suivre pour les obtenir.

Il est évident qu'afin de garder ce catalogue à jour, le Volume de Référence sera complètement révisé et publié deux fois par an.

VOLUME I

Ce volume est constitué par les specifications pour les composants faits par Motorola avec les numéros homologués par EIA jusqu'à 1N4999 et 2N4999. Ces spécifications sont classées par ordre numérique sauf les spécifications qui se rapportent à plusieurs types de dispositifs. Un index numérique en première page permet à l'utilisateur de déterminer rapidemente le numéro de la page pour chaque dispositif décrit dans ce catalogue.

Il est probable que les dispositifs portant un numéro en-dessous de 5000 nécessiteront peu de mise à jour puisque tous ces numéros sont déjà utilisés. En conséquence, ce volume ne sera réimprimé que sur demande et les modifications apparaîtront uniquement lors de cette nouvelle édition.

VOLUME II

Ce volume est constitué par toutes les spécifications pour les dispositifs faits par Motorola, homologués par EIA avec numéros 1N5000, 2N5000, etc. ainsi que ceux avec les numéros 3N---. De plus, les spécifications de dispositifs avec numéros spéciaux de Motorola (non homologués par EIA) y sont incluses.

Ce catalogue sera mis à jour à l'aide d'éditions supplémentaires, car il contient toutes les données détaillées des dispositifs semiconducteurs les plus récents.

Méthode d'Utilisation du Catalogue de Semiconducteurs

Ce catalogue a pour but:

1. D'identifier rapidement, grâce aux spécifications principales, si le dispositif est homologué par EIA ou s'il s'agit d'un type spécial Motorola.
2. De sélectionner rapidement le dispositif le mieux adapté à un circuit.
3. De sélectionner rapidement un dispositif en fonction des spécifications électriques.
4. De fournir les données complètes de tout l'ensemble des composants Motorola – donc la majorité des dispositifs semiconducteurs – afin de pouvoir comparer tous les types de dispositifs.

Exemples de méthodes d'utilisation;

Question: Identifier le dispositif
Donnée: Type de dispositif
Renseignements Requis: Fonction du dispositif, applications et spécifications principales.

Méthode: Consulter l'Index du Volume de Référence et déterminer le numéro du dispositif en question parmi la liste numérique de l'index. Ce renseignement ainsi obtenu indique non seulement le type de dispositif mais également fournit les spécifications électriques principales de ce dispositif. De plus, le fabricant y sera précisé et le catalogue indiquera si Motorola peut fournir les dispositifs équivalents. Les deux autres volumes de ce catalogue vont maintenant fournir toutes les données sur les dispositifs faits par Motorola.

Question: Choix du Dispositif

Données:

a) Application probable du circuit pour un dispositif connu.

b) Spécifications électriques approximatives du dispositif en question.

Renseignements Requis:

a) Quels sont les dispositifs disponibles pour la fonction précise de ce circuit?
b) Quel type de dispositif va répondre à des caractéristiques électriques prédéterminées?

Méthode: Consulter le Guide dans le Volume de Référence qui est catégorisé par produits, c'est-à-dire transistors de puissance, diodes zener, etc., et par marchés, y compris communications, grand public, et militaire. Ces différentes catégories apparaissent en première page pour faciliter la sélection du Guide. Nous pouvons maintenant obtenir toutes les données sur les dispositifs faits par Motorola en utilisant les deux autres volumes du Catalogue de Semiconducteurs.

DIE HALBLEITER DATENBIBLIOTHEK

Eines der Hauptprobleme für Fachleute in der Elektronik-Industrie besteht in der Bestimmung und Selektion von Halbleitertypen. Die meisten Typenbezeichnungen geben wenig oder keine Auskunft über Parameter oder Anwendungen von speziellen Halbleitern. Viele tausend verschiedene Halbleitertypen sind heute erhältlich. Es ist fast unmöglich, auch nur einen geringen Prozentsatz aller Typen genau zu kennen. Somit bringen die meisten Ingenieure und Techniker nur die bekanntesten und gebräuchlichsten Halbleitertypen zur Anwendung, auch wenn neuere und bessere Elemente zur Verfügung stehen.

Um diesem Problem Abhilfe zu schaffen hat Motorola die meisten Halbleitertypen in eine Halbleitersammlung zusammengefasst. Diese Halbleitersammlung umfasst alle 1N, 2N, 3N und 4N Typen, die durch die "Electronics Industries Association" registriert sind. Weiterhin sind eine grosse Anzahl von Motorola In-Haus Typen in dieser Sammlung zusammengefasst. Vollständige Spezifikationen einer grossen Anzahl von diskreten Halbleitern und Kuzspezifikationen von integrierten Schaltkreisen sind vorhanden.

Zusätzlich sind, zur Vereinfachung der Aufsuche der meist gebrauchten Halbleitertypennummern, Nachschlagetabellen mit Vorzugstypen für bestimmte Anwendungen in der Sammlung enthalten.

Die Halbleitersammlung kann dem Entwicklungs und Komponent-Ingenieur sowie dem Einkäufer von Halbleitern gute Dienste leisten im Aufsuchen der best möglichen Elemente für eine bestimmte Anwendung.

ZUSAMMENSETZUNG DER HALBLEITERSAMMLUNG

Die Halbleitersammlung besteht aus drei Teilen, die folgendermassen zusammengefasst sind:

REFERENZ-BAND

Der Referenz-Band besteht aus einer übersichtlichen Zusammenfassung von Halbleitern und integrierten Schaltungen. Mit Hilfe dieses Referenzbandes lassen sich Halbleiter und integrierte Schaltungen für spezielle Anwendungszwecke leicht auffinden. Gehäuse-, Anwendungs- und Montagezubehörinformation sind ebenso im Referenzband angegeben. Nach der Wahl eines Halbleiters oder einer integrierten Schaltung aus dem Referenzband kann Band I oder Band II für die speziellen Daten zur Hilfe gezogen werden.

EIA Registriertes Halbleiter-Verzeichnis

Vollständiges numerisches Verzeichnis aller EIA registrierter Halbleiter Typen, mit den hauptsächlichen elektrischen Spezifikationen.

Nicht Registriertes Halbleiter-Verzeichnis

Vollständiges numerisches Verzeichnis aller nicht registrierter In-Haus Motorola Halbleiter Typen, mit den hauptsächlichen elektrischen Spezifikationen.

Hauptnachschlagewerk

Zusammenfassung in Gruppen der bevorzugten Hauptelementkategorien für schnelle Vorselektion der Elemente die am besten für gegebene Anwendungen in Frage kommen. Dieses Dokument enthält Halbleiterelemente und integrierte Kreise.

Militärelementen-Liste

Dies ist eine vollständige Liste von Motorola Bausteinen die Militärspezifikationen erfüllen.

Montagezubehör und Einkapselung Information

Bauelement-Montagezubehör, Kühlelemente und Spezial-Elementeneinkapselung.

Vermasste Elementen-Grundrisse

Vermasste Zeichnungen von Gehäusegrundrissen mit JEDEC und Motorola Gegenüberstellung. (Zeichnungen der Anschlussformen von gegebenen Gehäusen sind inbegriffen.)

Awendungsbericht-Katalog

Nachschlagliste der Anwendungsberichte welche in Anwendungskategorien zusammengefasst sind. Eine kurze Zusammenfassung des Inhalts der verfügbaren Berichte ist gegeben und ebenfalls wie sie bestellt werden können.

Um den Anforderungen eines praktischen, auf den letzten Stand gebrachten Nachschlagewerkes zu genügen wird der Referenz-Band der Halbleiterbibliothek zweimal im Jahr vollständig überarbeitet und publiziert.

BAND I

Dieser Band enthält vollständige Datenblätter der von Motorola fabrizierten Elemente mit EIA registrierten Nummern bis zu 1N4999 und 2N4999. Die Datenblätter sind in numerischer Ordnung gemäss der Bauelemente-Typennummer eingereiht. Ausnahme sind solche Datenblätter welche spezielle Elemente mit wechselnden Typennummern behandeln. Ein numerisches Verzeichnis am anfang des Bandes erlaubt dem Benützer ein schnelles Auffinden der Datenblätter für alle Elemente, die im Buch aufgeführt sind.

Weil die meisten Elemente-Typennummern in der Kategorie bis 5000 schon von bestehenden Produkten aufgebraucht wurden, ist erwartet, dass dieser Band in den nächsten Jahren wenig Ueberarbeitung verlangt. Dementsprechend wird dieses Buch nur neu gedruckt wenn die Nachfrage es verlangt und Modifikationen werden nur bei einer Neuauflage vorgenommen.

BAND II

Dieser Band enthält Datenblätter der von Motorola hergestellten EIA registrierten Elemente mit der Typennummer 1N5000 und 2N5000 und aufwärts und ebenfalls solche mit den 3N- - Typennummern. Alle aktiven Datenblätter für Elemente mit speziellen Motorola Typennummern (nicht EIA registriert) sind zusätzlich

hier einbezogen.

Weil dieser Band die detaillierten Daten für alle der erst kürzlich entwickelten Halbleiter enthält, wird er durch Publikationen von Zusatzbüchern auf den letzten Stand gebracht.

Wie wird "Die Halbleiter Datenbibliothek" gebraucht

Die Bibliothek ist zusammengestellt worden um mehrere spezielle Funktionen zu erfüllen:

1. Erlaubt schnelle Bestimmung (zusammen mit Hauptspezifikationen) von EIA registrierten Halbleitern und Bausteinen mit speziellen Motorola Typennummern.
2. Erlaubt schnelle Selektion der best geeignetsten Elemente für eine bestimmte Schaltungsanwendung.
3. Erlaubt schnelle Selektion von Elementen welche am besten gegebene elektrische Spezifikationen erfüllen.
4. Liefert vollständige Charakterisation einer breiten Komponentenlinie, welche die meisten Halbleiter-Kategorien einschliesst. Erlaubt einen detaillierten Vergleich der Elementtypen.

Die nachfolgenden Beispiele veranschaulichen mehrere Wege um diese Bibliothek zu gebrauchen.

Problem: Elementen-Bestimmung
Bekannt: Elemente-Typennummer
Benötigte Information: Elementefunktion, Anwendung, Hauptspezifikationen

Vorgang: Im Hauptverzeichnis des Referenzbandes sind die Typennummern des zu untersuchenden Elementes in der alphanumerischen Liste aufgefuhrt. Die Information, die in diesem Verzeichnis gegeben ist, besteht nicht nur aus dem Elemententyp sondern auch die elektrischen Hauptspezifikationen sind gegeben. Zusätzlich ist angegeben ob das Element von Motorola hergestellt wird und, im Fall dass dies verneint wird, ob Motorola ein elektrisch vergleichbares Bauelement liefern kann. Wenn benötigt, können die vollständigen Daten der von Motorola hergestellten Halbleiter von den zwei anderen Bänden der Halbleiter Bibliothek erhalten werden.

Problem: Elementen-Vorbestimmung
Bekannt:

a) Vorgesehene Schaltkreisanwendung für ein bestimmtes Element.
b) Ungefähre elektrische Spezifikationen eines gewünschten Typs.

Benötigte Information:

a) Welche Elemente sind für eine bestimmte Kreisfunktion verfügbar?
b) Welche Elementtypen erfüllen am besten die erforderlichen elektrischen Charakteristiken?

Vorgang: Das Hauptnachschlagwerk des Referenzbandes wird aufgeschlagen. Dieses Kapitel enthält Produktkategorien, z.B. Leistungstransistoren, Zenerdioden etc. eingereiht in bestimmte Marktsegmente, einschliesslich Fernmeldewesen, Verbraucherindustrie und Militärbereich. Ein "Index" zu den einzelnen "Auswahl-Führern" ist am anfang dieses Kapitels gegeben, was zum schnellen Auffinden der zutreffenden "Führer" hilft. Vollständige Daten der von Motorola hergestellten Elemente können, wenn benötigt, von den zwei anderen Bänden entnommen werden.

THE SEMICONDUCTOR DATA LIBRARY
(半導体データ ライブラリー)

電子工業にたずさわっているものが直面する難問の1つは、半導体製品の分類と選択である。個々の製品の型番号はその製品のパラメータや用途を直接示すものではないので大して役には立たない。

特定の用途に対して製品のメリットを検討することなどは云うにおよばず、数万にのぼる型番号を分類することも非常に困難なことである。したがって新製品やより適切な製品があるにも拘らず、技術者が設計にあたって採用するのは少数のよく知られている製品に限られてしまうことがよくある。このライブラリは、このような問題を解決するために編集されたものである。

このライブラリはＥＩＡ（電子工業会）に登録された IN‥‥, 2N‥‥, 3N‥‥, 4N‥‥‥番号をもつすべてのディスクリート（半導体製品）と登録外のモトローラ製品を巾広く分類し、その特性を収録している。

またＩＣ製品についても概略データが記載されている。

さらに最も適当な製品を簡単に選択できるように用途別に推薦製品をセレクタ・ガイドとして紹介しているので、設計技術者、部品技術者および購買担当者は膨大な半導体製品の中から特定のプロジェクトに最も適したものだけにしぼることができる。

ライブラリの構成

このライブラリは3巻に分れ次のように構成されている。

REFERENCE VOLUME (リファレンス・ボリューム)

この巻は半導体製品とＩＣ製品の完全な概略データを収録しているので、ユーザーはどんな用途や回路に使う素子でも選び出すことができる。またパッケージ、取付け部品および応用例も記載されている。この巻で適当な素子をあらかじめ選び出すと、第1巻および第2巻でそれらの詳細なデータを調べることができる。

ＥＩＡ登録製品の索引　ＥＩＡ（電子工業会）に登録された全製品の完全な番号順索引と主な電気特性。

ＥＩＡ登録外製品の索引　モトローラ社の標準規格品の完全な番号順索引と主な電気特性。

マスタ・セレクション・ガイド　半導体製品とIC製品を含め、最適な素子が簡単に選び出せるよう用途別に分類されている。

政府用製品リスト　政府の仕様によるモトローラ製品の完全なリスト。

取付け部品とパッケージング　取付け部品、ヒート・シンクおよび特別品のパッケージング。

ケースの概略平面図　ＪＥＤＥＣとモトローラ製品の互換性データとケースの概略平面図（特定のパッケージのリードフォームの図を含む。）

アプリケーション・ノート・カタログ　用途別アプリケーション・ノートのセレクション・ガイドと各ノートの要約および注文方法。

最新情報に対する要望に応えるため、この巻は年2回発行され完全な最新情報を収録している。

VOLUME I (第1巻)

第1巻はＥＩＡに登録されたＩＮ４９９９および２Ｎ４９９９までのモトローラ製品の完全なデータを収録している。数種の製品番号をまとめて記載しているデータ・シートを除いてはすべて番号順に整理されている。巻頭の番号順索引から、第1巻中のどの製品についてもデータ記載ページが簡単に調べられる。

５０００以下の型番号に対しては既にほとんど製品ができているので、この巻は2、3年後も再版の必要はないと思われる。したがって必要がある場合にのみ再版され、修正が加えられる。

VOLUME II (第2巻)

第2巻はＩＮ５０００と２Ｎ５０００以上および3Nの型番号でＥＩＡに登録されたモトローラ製品と、登録外のモトローラ標準規格品の全データ・シートを収録している。第2巻にはごく最近開発された半導体製品の詳細なデータまで収録され、なお　増補版　が追加されるので、つねに最新のデータが得られる。

半導体データ・ライブラリの使用法

このライブラリは次のように使える。

1) ＥＩＡに登録された半導体製品とモトローラ社の型番号をもった製品が容易に確認でき、主な特性を調べることができる。

2) 特定の回路応用例に対して最適の製品を迅速に選び出すことができる。

3) 指定された電気特性に最もよくあう製品を容易に選択できる。

4) 広範囲にわたる半導体製品の完全な特性を収録しているので、詳細にわたって製品の比較ができる。

具体的な使用例を紹介してみよう.

例： 製品の確認

わかっていること ： 型番号

調べたいこと ： 製品の機能、応用例、特性

方　法 ： まず、リファレンス・ボリュームのマスタ・インデックスをひき、アルファベット番号順リストで、自分の製品番号をみつける. この索引では製品の型番号だけでなく、主な電気特性およびモトローラ製かどうかということも表示している. もしモトローラ製品でない場合は、電気的に適当な同等品があるかどうかがわかる. モトローラ製品の完全なデータが必要な場合は、半導体データ・ライブラリの第1巻および第2巻から調べることができる.

例：製品の予備選択

わかっていること：

a) 特定の製品に対する応用企画.

b) 必要な電気的特性.

調べたいこと：

a) 目的にあう製品にはどんなものがあるか.

b) どんなタイプの製品が最適であるか.

方　法： まず、リファレンス・ボリュームのマスタ・セレクション・ガイドの章をみる. この章は通信機器用、民生機器用、政府用機器を含めて、パワ・トランジスタあるいはゼナー・ダイオード等種類別に記載されている. この章の第1ページにはセレクタ・ガイドがついており使いやすい. モトローラ製品の完全なデータが必要な場合は、半導体データ・ライブラリの第1巻および第2巻から調べることができる.

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MZ1000-21		
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MZ1000-24		
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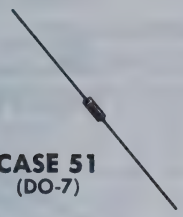
1N... JEDEC REGISTERED DEVICE SPECIFICATIONS

DIODES
- Zener
- 4-Layer
- Current Regulator

POWER VARACTORS
- Tuning Diodes

TRIGGERS

1N5139,A thru 1N5148,A (SILICON)



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable capacitance diodes, designed for electronic tuning and harmonic-generation applications, and providing solid-state reliability to replace mechanical tuning methods.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Vdc
Forward Current	I_F	250	mAdc
RF Power Input†	P_{in}†	5.0	Watts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_C	2.0 13.3	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

† The RF power input rating assumes that an adequate heat sink is provided.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic – All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	B_{VR}	60	70	—	Vdc
Reverse Voltage Leakage Current	V_R = 55 Vdc, T_A = 25°C V_R = 55 Vdc, T_A = 150°C	I_R	— —	— —	0.02 20	μAdc
Series Inductance	f = 250 MHz, L ≈ 1/16"	L_S	—	5.0	—	nH
Case Capacitance	f = 1 MHz, L ≈ 1/16"	C_C	—	0.25	—	pF
Diode Capacitance Temperature Coefficient	V_R = 4 Vdc, f = 1 MHz	TC_C	—	200	300	ppm/°C

	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz	α V_R = 4 Vdc, f = 1 MHz		TR, Tuning Ratio C_4/C_{60} f = 1 MHz	
Device	Min	Typ	Max	Min	Min	Typ	Min	Typ
1N5139	6.1	6.8	7.5	350	0.37	0.40	2.7	2.9
1N5139A	6.5	6.8	7.1	350	0.37	0.40	2.7	2.9
1N5140	9.0	10.0	11.0	300	0.38	0.41	2.8	3.0
1N5140A	9.5	10.0	10.5	300	0.38	0.41	2.8	3.0
1N5141	10.8	12.0	13.2	300	0.38	0.41	2.8	3.0
1N5141A	11.4	12.0	12.6	300	0.38	0.41	2.8	3.0
1N5142	13.5	15.0	16.5	250	0.38	0.41	2.8	3.0
1N5142A	14.3	15.0	15.7	250	0.38	0.41	2.8	3.0
1N5143	16.2	18.0	19.8	250	0.38	0.41	2.8	3.0
1N5143A	17.1	18.0	18.9	250	0.38	0.41	2.8	3.0
1N5144	19.8	22.0	24.2	200	0.43	0.45	3.2	3.4
1N5144A	20.9	22.0	23.1	200	0.43	0.45	3.2	3.4
1N5145	24.3	27.0	29.7	200	0.43	0.45	3.2	3.4
1N5145A	25.7	27.0	28.3	200	0.43	0.45	3.2	3.4
1N5146	29.7	33.0	36.3	200	0.43	0.45	3.2	3.4
1N5146A	31.4	33.0	34.6	200	0.43	0.45	3.2	3.4
1N5147	36.1	39.0	42.9	200	0.43	0.45	3.2	3.4
1N5147A	37.1	39.0	40.9	200	0.43	0.45	3.2	3.4
1N5148	42.3	47.0	51.7	200	0.43	0.45	3.2	3.4
1N5148A	44.7	47.0	49.3	200	0.43	0.45	3.2	3.4

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

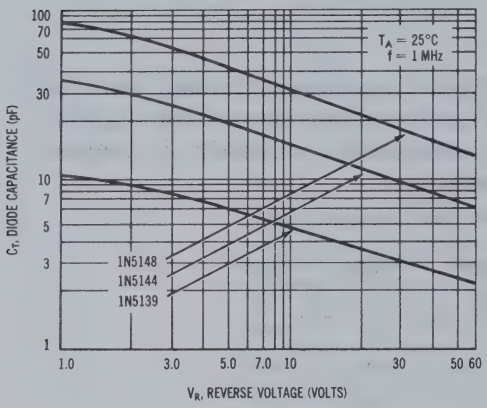


FIGURE 2 — FIGURE OF MERIT versus REVERSE VOLTAGE

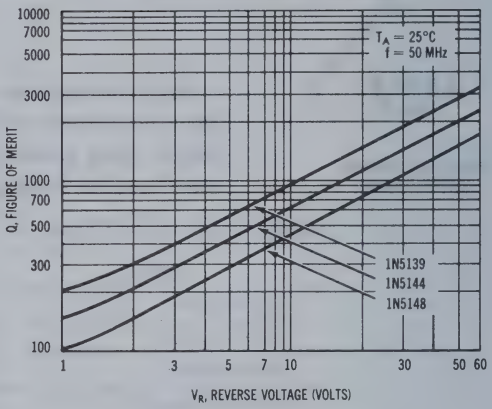


FIGURE 3 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

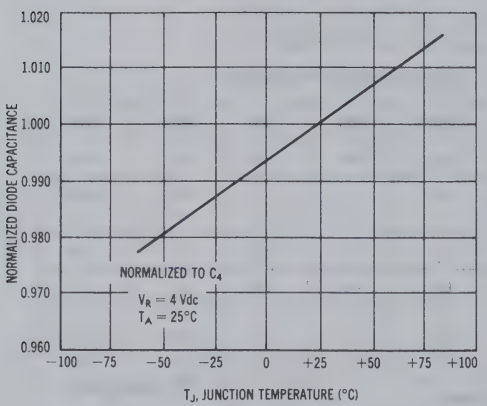


FIGURE 4 — NORMALIZED FIGURE OF MERIT versus JUNCTION TEMPERATURE

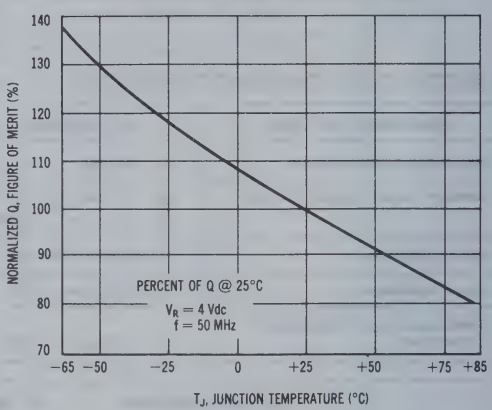


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

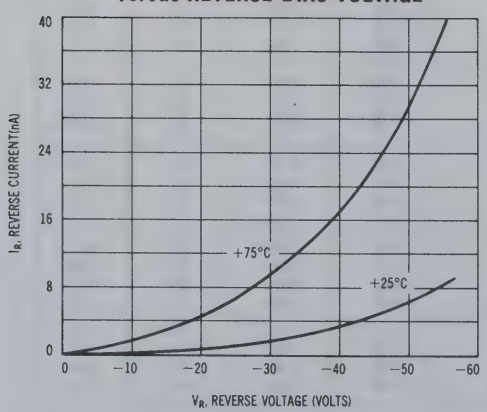
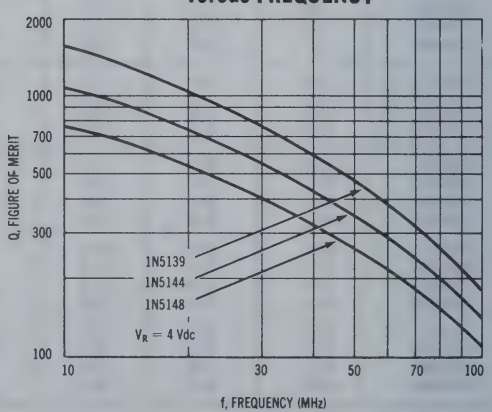


FIGURE 6 — FIGURE OF MERIT versus FREQUENCY



1N5149 (SILICON)
(MV1806C)

1N5150
(MV1807C)

Silicon high-frequency step-recovery power varactors for 100 MHz to 2.0 GHz harmonic-generation applications with output power to 25 watts at 1.0 GHz.

CASE 47



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	80	Vdc
Forward Current		I_F	1.0	Amp
RF Power Input	1N5149 1N5150	P_{in}	25 40	Watts
Total Device Dissipation @ T_A = 75°C	1N5149 1N5150	P_D	10 14	Watts
Derate above 75°C	1N5149 1N5150		0.08 0.11	W/°C
Junction Temperature		T_J	+200	°C
Storage Temperature Range		T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	80	90	—	Vdc
Reverse Current	I_R	V_R = 70 Vdc	—	—	2.0	μAdc
		V_R = 70 Vdc, T_A = 150°C	—	—	100	
Diode Capacitance	C_T	V_R = 6 Vdc, f = 1.0 MHz	5.0	11.5	20	pF
Figure of Merit	Q	V_R = 6 Vdc, f = 50 MHz	—	800	—	—
Thermal Resistance	θ_{JC}	IN5150	—	—	9.0	°C/W

FUNCTIONAL TEST

1N5149

RF Power Output	P_{out}	Test Setup Figure 1 P_{in} = 20 W f_{in} = 0.5 GHz f_{out} = 1.0 GHz	11	—	—	Watts
Doubler Efficiency	η		55	—	—	%

1N5150

RF Power Output	P_{out}	Test Setup Figure 1 P_{in} = 37 W f_{in} = 0.5 GHz f_{out} = 1.0 GHz	24	25	—	Watts
Doubler Efficiency	η		65	68	—	%

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

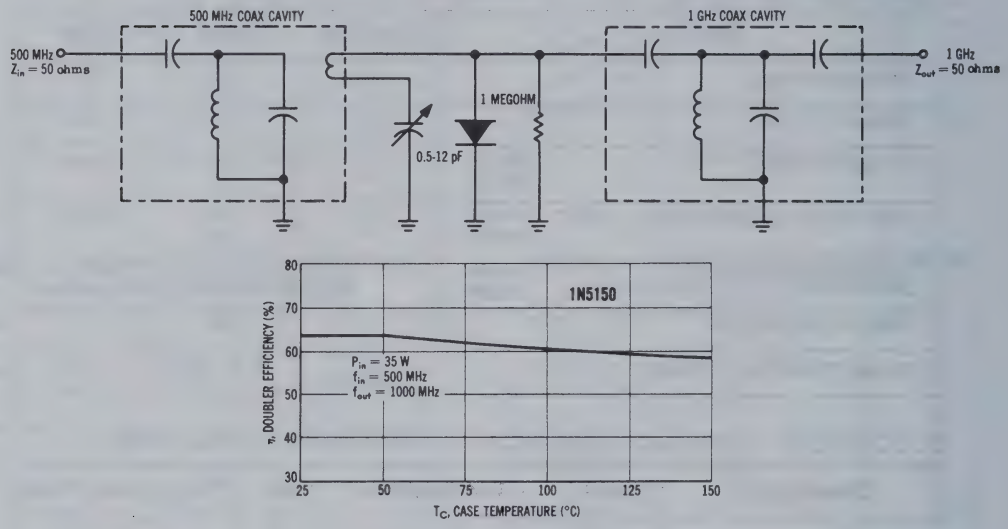


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING

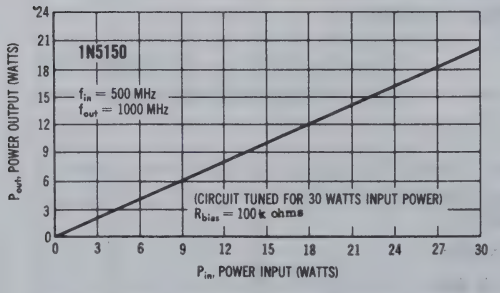
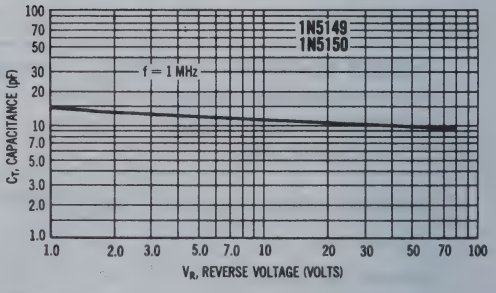


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE



POWER OUTPUT versus OUTPUT FREQUENCY

1N5149

FIGURE 4A — DOUBLING (X2)

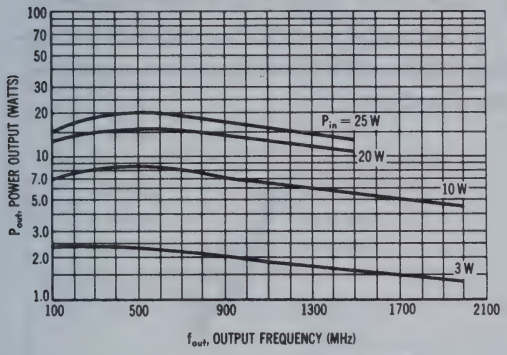


FIGURE 4B — TRIPLING (X3)

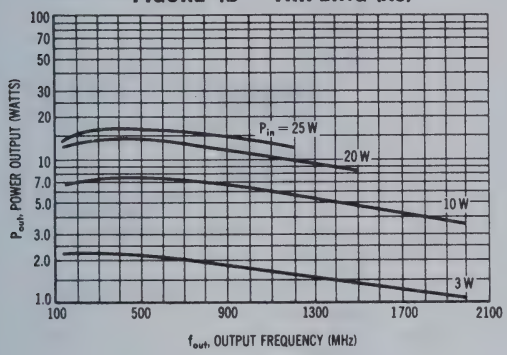
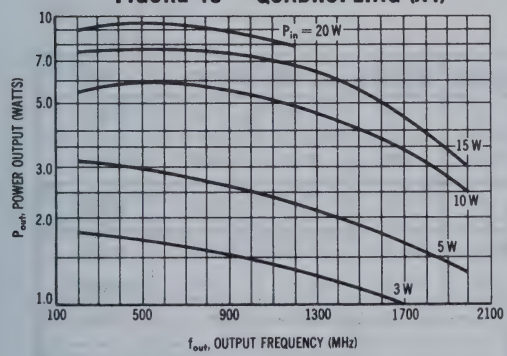


FIGURE 4C — QUADRUPLING (X4)



1N5150

FIGURE 5A — DOUBLING (X2)

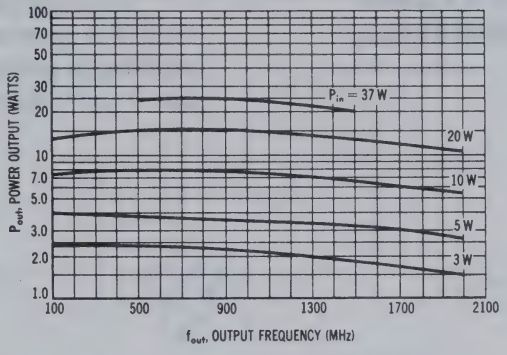


FIGURE 5B — TRIPLING (X3)

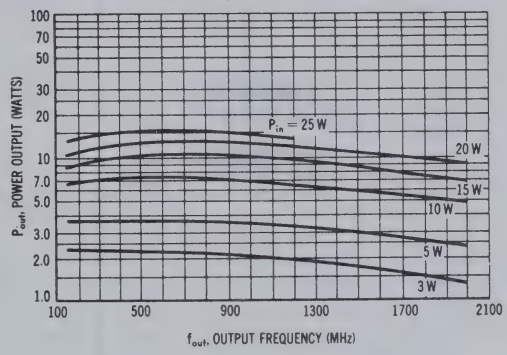
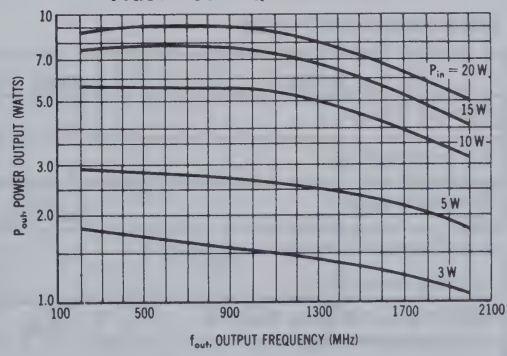


FIGURE 5C — QUADRUPLING (X4)



1N5150A (SILICON)
(MV1807C1)
1N5152A
(MV1808B1)
1N5153A
(MV1808C1)
1N5155A
(MV1810B1)

Silicon high-frequency step-recovery power varactor devices optimized for critical multiplier applications requiring tight control of junction capacitance and power dissipation.



CASE 46

1N5152A
MV1808B1

1N5155A
MV1810B1



CASE 47

1N5150A
MV1807C1

1N5153A
MV1808C1

MAXIMUM RATINGS

Rating	Symbol	1N5150A	1N5152A	1N5153A	1N5155A	Unit
Reverse Voltage	V_R	80	75	75	35	Vdc
Forward Current	I_F	1000	250	250	200	mAdc
RF Power Input	P_{in}	40	15	15	7.0	Watts
Total Device Dissipation @ T_C = 25°C	P_D	29.2	11.7	11.7	8.75	Watts
Derate above 25°C		167	66.7	66.7	50	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage		BV_R				Vdc
(I_R = 10 μAdc)	1N5150A		80	-	-	
	1N5152A, 1N5153A		75	-	-	
	1N5155A		35	-	-	
Reverse Current		I_R				μAdc
(V_R = 70 Vdc)	1N5150A		-	-	2.0	
(V_R = 70 Vdc, T_A = 150°C)	1N5150A		-	-	100	
(V_R = 60 Vdc)	1N5152A, 1N5153A		-	-	1.0	
(V_R = 60 Vdc, T_A = 150°C)	1N5152A, 1N5153A		-	-	100	
(V_R = 26 Vdc)	1N5155A		-	-	1.0	
(V_R = 26 Vdc, T_A = 150°C)	1N5155A		-	-	100	
Series Resistance		R_S				Ohms
(V_R = 6.0 Vdc, f = self-resonant frequency)						
	1N5150A		-	0.25	-	
	1N5152A, 1N5153A		-	0.5	-	
	1N5155A		-	0.9	-	
Series Inductance		L_S				nH
	1N5150A		-	1.5	-	
	1N5152A		-	0.8	-	
	1N5153A		-	1.7	-	
	1N5155A		-	0.9	-	
Diode Capacitance ($C_J + C_C$)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	1N5150A		10.8	-	13.2	
	1N5152A		5.4	-	6.6	
	1N5153A		5.8	-	7.0	
	1N5155A		1.71	-	2.09	
Figure of Merit		Q				-
(V_R = 6.0 Vdc, f = 50 MHz)	1N5150A		-	800	-	
	1N5152A, 1N5153A		-	1100	-	
	1N5155A		-	1700	-	
Thermal Resistance		θ_{JC}				°C/W
	1N5150A		-	-	6.0	
	1N5152A, 1N5153A		-	-	15	
	1N5155A		-	-	20	

FUNCTIONAL TEST

1N5150A

RF Power Output	P_{in} = 37 W, f_{in} = 500 MHz,	P_{out}	25.1	-	-	Watts
Doubling Efficiency	f_{out} = 1.0 GHz	η	68	-	-	%

1N5152A, 1N5153A

RF Power Output	P_{in} = 12 W, f_{in} = 1.0 GHz,	P_{out}	7.2	-	-	Watts
Doubling Efficiency	f_{out} = 2.0 GHz	η	60	-	-	%

1N5155A

RF Power Output	P_{in} = 5.0 W, f_{in} = 2.0 GHz,	P_{out}	2.0	-	-	Watts
Tripling Efficiency	f_{out} = 6.0 GHz	η	40	-	-	%

For typical curves and test circuits, see the following data sheets: 1N5149-1N5150, 1N5151 thru 1N5153, and 1N5154-1N5155.

1N5151 (SILICON)
(MV1808A)

1N5152
(MV1808B)

1N5153
(MV1808C)

Silicon high-frequency step-recovery power varactors, designed for high-power, high-frequency harmonic generation applications.



CASE 48
(1N5151)
(pill)



CASE 46
(1N5152)
(pill with prongs)



CASE 47
(1N5153)
(cartridge)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	0.25	Adc
RF Power Input	P_{in}	15	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	5.5 45	Watts mW/°C
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Condition	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	75	80	–	Vdc
Reverse Current	V_R = 60 Vdc	I_R	–	0.5	1.0	μAdc
	V_R = 60 Vdc, T_A = 150°C		–	–	100	
Series Resistance	V_R = 6 Vdc, f = 50 MHz	R_S	–	0.5	–	Ohms
Diode Capacitance	V_R = 6 Vdc, f =1.0MHz	C_T*	5.0	5.8	7.5	pF
	V_R = 70 Vdc, f =1.0MHz		–	4.0	–	
Figure of Merit	V_R = 6 Vdc, f = 50 MHz	Q	–	1100	–	–
Power Output	DOUBLER TEST CIRCUIT (Figure 1) P_{in} = 12 W, f_{in} = 1GHz f_{out} = 2 GHz	P_{out}	6.0	7.2	–	Watts
Efficiency		η	50	60	–	%
Thermal Resistance		θ_J	–	19	23	°C/Watt

*$C_T = C_J + C_C$

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

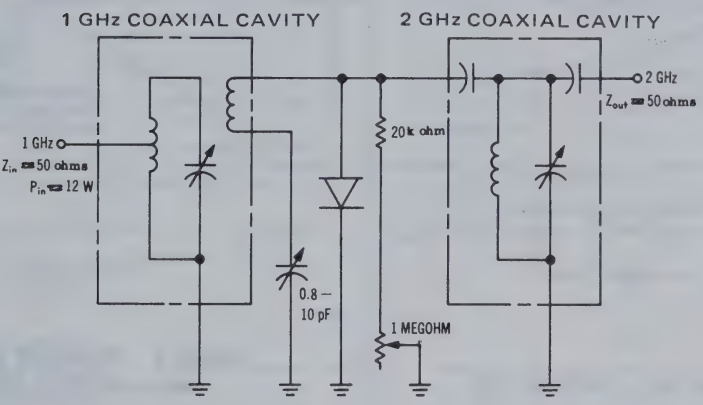
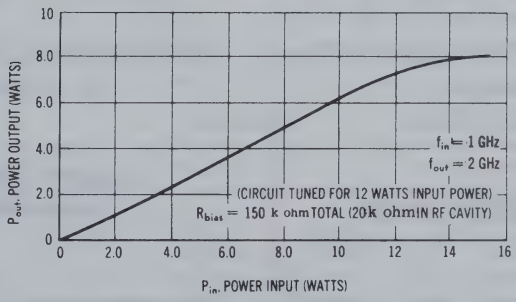


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING



POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 3A — DOUBLING (X2)

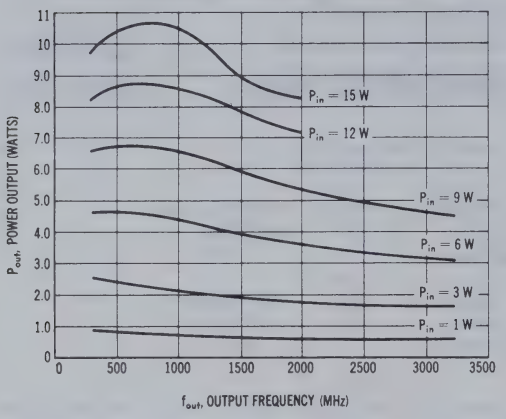


FIGURE 3B — TRIPLING (X3)

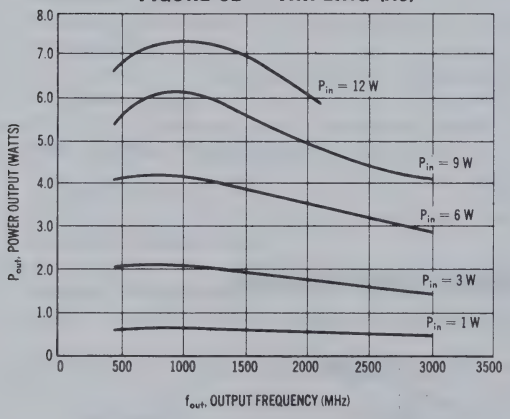
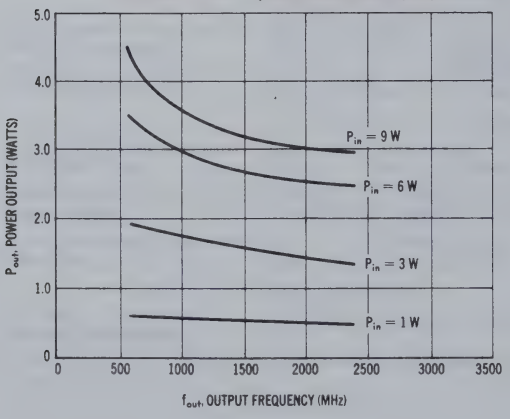


FIGURE 3C — QUADRUPLING (X4)



TYPICAL CHARACTERISTICS at 25°C

FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

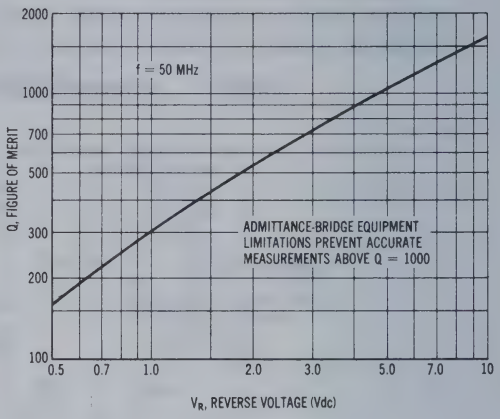


FIGURE 5 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

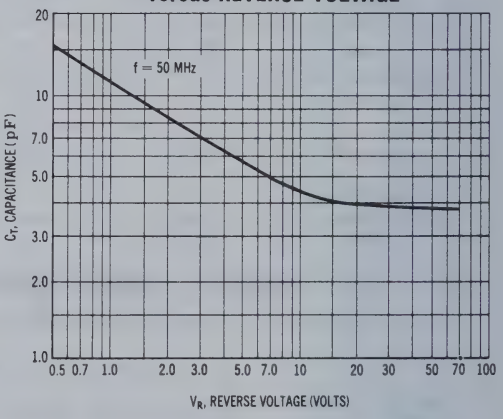
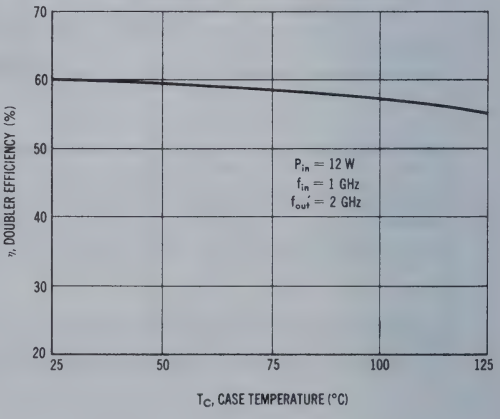


FIGURE 6 — DOUBLER EFFICIENCY versus CASE TEMPERATURE



1N5154 (SILICON)
(MV1810A)
1N5155
(MV1810B)

CASE 48
(1N5154)
(pill)



CASE 46
(1N5155)
(pill with prongs)



Silicon high-frequency step-recovery power varactors, for multiplier applications from 2 to 8.5 GHz with 2 watts minimum power output guaranteed at 6 GHz.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc
Forward Current	I_F	200	mAdc
RF Power Input	P_{in}	7.0	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	3.5 30	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	35	45	—	Vdc
Reverse Current	V_R = 26 Vdc V_R = 26 Vdc, T_A = 150°C	I_R	— —	— —	1.0 100	μAdc
Series Resistance	V_R = 6 Vdc, f = 50 MHz	R_S	—	0.9	—	Ohms
Diode Capacitance	V_R = 6 Vdc, f = 1 MHz	C_T	1.0	2.1	3.0	pF
Figure of Merit	V_R = 6 Vdc, f = 50 MHz	Q	—	1700	—	—
Thermal Resistance		θ_{JC}	—	—	35	°C/W

FUNCTIONAL TEST

RF Power Output	Test Circuit Figure 5 P_{in} = 5 watts, f_{in} = 2 GHz, f_{out} = 6 GHz	P_{out}	2.0	—	—	Watts
Tripling Efficiency		η	40	—	—	%

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 1A — DOUBLING (X2)

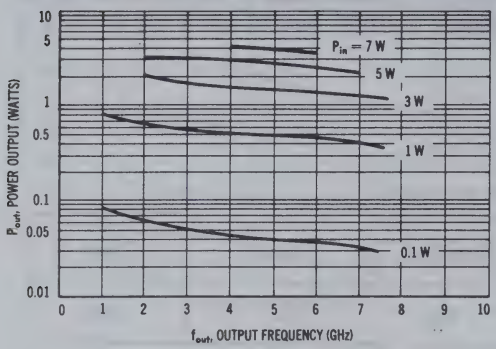


FIGURE 1B — TRIPLING (X3)

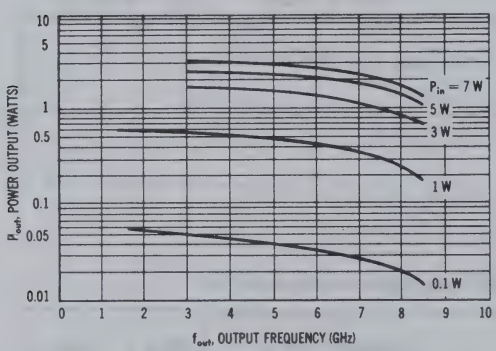
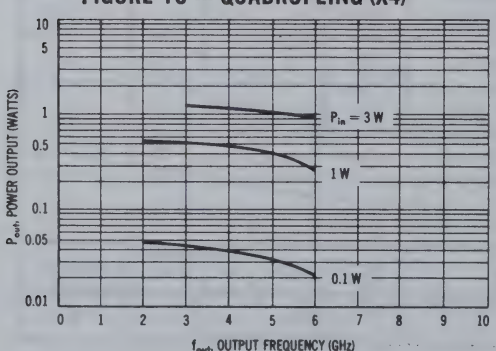


FIGURE 1C — QUADRUPLING (X4)



TYPICAL CHARACTERISTICS $T_C = 25°C$

FIGURE 2 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

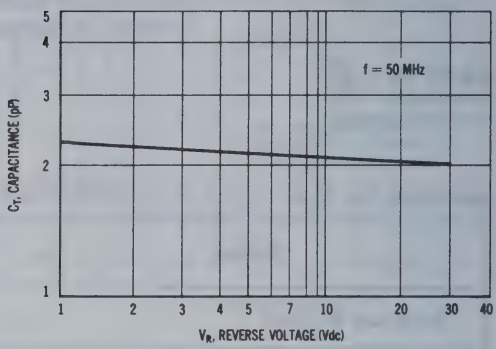


FIGURE 3 — TRIPLER POWER OUTPUT versus TEMPERATURE 2 GHz to 6 GHz

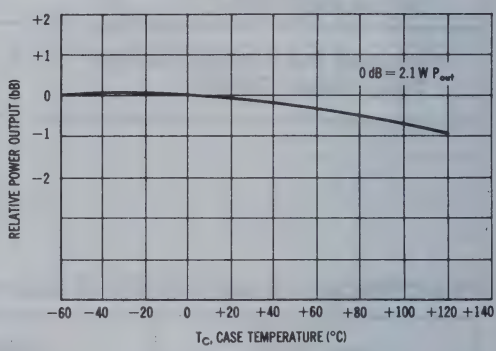


FIGURE 4 — TRIPLER LINEARITY CHARACTERISTIC

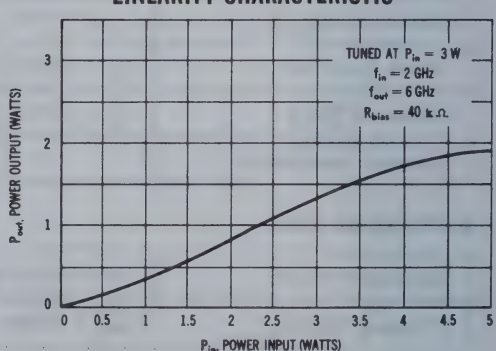


FIGURE 5 — HARMONIC TRIPLER — 2 GHz to 6 GHz

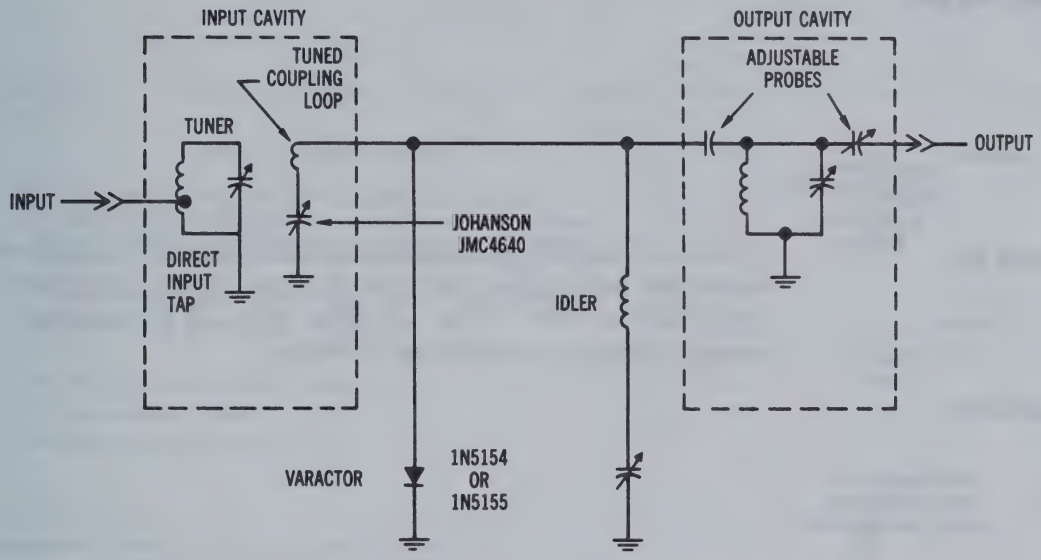
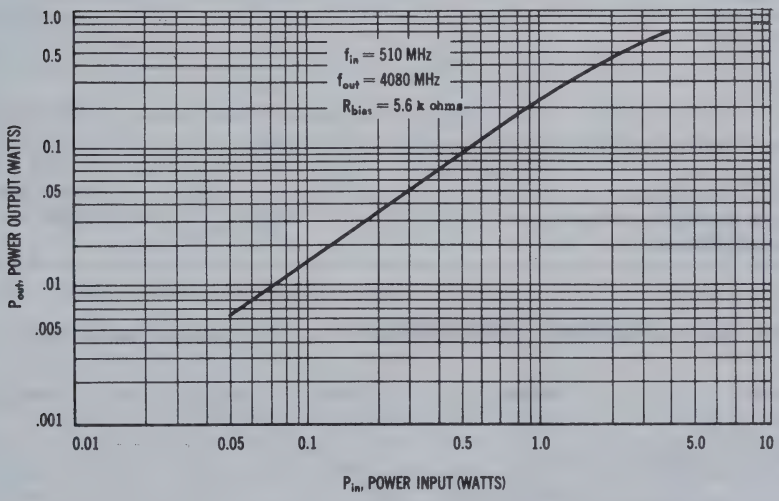
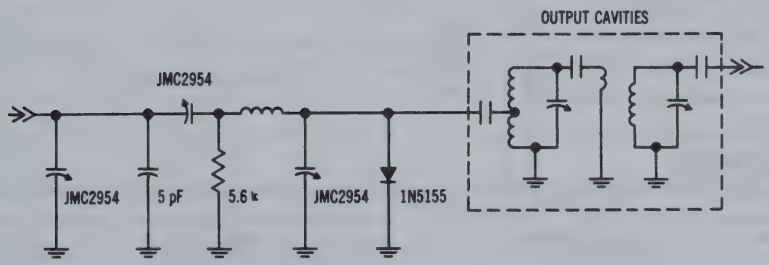


FIGURE 6 — HARMONIC OCTUPLER — 510 MHz to 4080 MHz

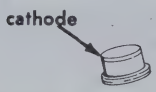




IN5156 (SILICON)
(MV1812A)
IN5157
(MV1812B)



CASE 46



CASE 48

Silicon high-frequency step-recovery power varactors; epitaxial-passivated devices designed for multiplier applications from 1.0 to 13 GHz with 1.0 W minimum power output guaranteed at 10 GHz.

AVAILABLE IN PILL PACKAGE ON SPECIAL REQUEST

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	160	mAdc
RF Power Input	P_{in}	5.0	Watts
Total Device Dissipation @ T_C = 75°C	P_D	3.25	Watts
Derate above 75°C		26	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	20	–	–	Vdc
Reverse Current	V_R = 16 Vdc	I_R	–	–	0.1	μAdc
	V_R = 16 Vdc, T_A = 150°C		–	–	100	
Series Resistance	V_R = 6.0 Vdc, f = 50 MHz	R_S	–	1.1	–	Ohms
Diode Capacitance	V_R = 6.0 Vdc, f = 1.0 MHz	C_T	0.6	–	1.0	pF
Figure of Merit	V_R = 6.0 Vdc, f = 50 MHz	Q	–	3600	–	–
Thermal Resistance		θ_{JC}	–	–	38.5	°C/W

FUNCTIONAL TEST

RF Power Output	P_{in} = 2.6 W , f_{in} = 5.0 GHz	P_{out}	1.0	–	–	Watt
Doubling Efficiency	f_{out} = 10 GHz	η	38.5	–	–	%

1N5158 thru 1N5160
1N5779 thru 1N5793

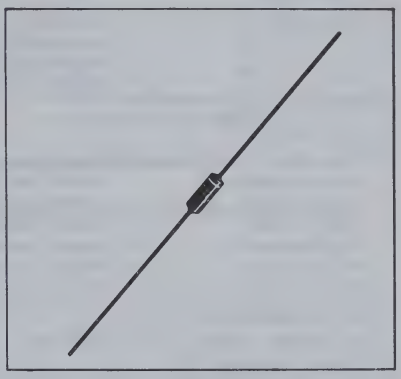
PNPN 4-LAYER DIODES

. . . two terminal, fast-switching devices specifically designed for low voltage applications such as logic circuits, pulse generators, memory and relay drivers, relay replacements, alarm circuits, multivibrators, ring counters, and telephone switching circuits. These devices feature:

- Low Breakover (Switching) Voltage — 10 to 15-Volt Ratings
- Fast Switching Speeds — t_{on} = 75 ns (Typ)
  t_{off} = 250 ns (Typ)
- Low Junction Capacitance — 45 pF (Typ)
- Low Breakover Currents
- Subminiature Glass Package

EPITAXIAL 4-LAYER DIODES

10-15 VOLTS
150 mW

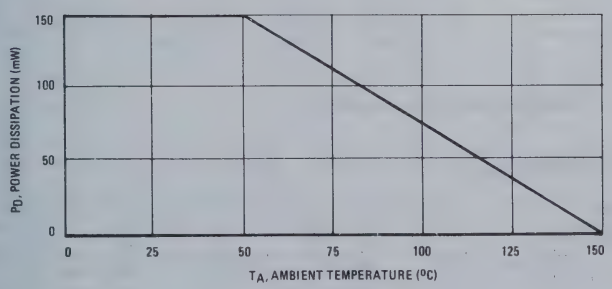


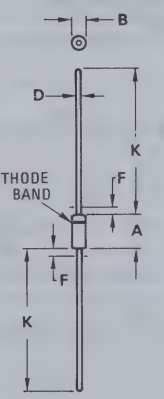
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
*Reverse Voltage 1N5158, 1N5782, 1N5788 1N5159, 1N5783, 1N5789 1N5160, 1N5784, 1N5790 1N5779, 1N5785, 1N5791 1N5780, 1N5786, 1N5792 1N5781, 1N5787, 1N5793	V_{RM}	10 11 12 13 14 15	Volts
*Continuous Forward Current	I_F	150	mA
*Steady State Power Dissipation @ T_A = 50°C Derate above 50°C	P_D	150 1.5	mW mW/°C
*Peak Pulse Current (50 μs maximum pulse width)	I_{pulse}	10	Amps
*Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	—	1.27	—	0.050
K	25.40	—	1.000	—

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Forward Switching Voltage	1N5158, 1N5782, 1N5788	V_S	8.0	–	10	Volts
	1N5159, 1N5783, 1N5789		9.0	–	11	
	1N5160, 1N5784, 1N5790		10	–	12	
	1N5779, 1N5785, 1N5791		11	–	13	
	1N5780, 1N5786, 1N5792		12	–	14	
	1N5781, 1N5787, 1N5793		13	–	15	
*Forward Switching Current	1N5158 thru 1N5160, 1N5779 thru 1N5781	I_S	–	5.0	50	μA
	1N5782 thru 1N5793		–	10	100	
*Forward Off-State Current (V_F = 0.75 x V_S)		I_{FM}	–	1.0	5.0	μA
*Reverse Current (V_R = V_{RM})		I_{RM}	–	2.0	10	μA
*Holding Current	1N5158 thru 1N5160, 1N5779 thru 1N5781	I_H	1.0	4.0	20	mA
	1N5782 thru 1N5787		10	–	50	
	1N5788 thru 1N5793		0.1	–	2.0	
*Forward On Voltage (I_F = 150 mAdc)		V_F	–	1.0	1.5	Volts
*Critical Rate of Rise of Applied Forward Voltage		dv/dt				V/μs
(V_S = 6.0 Vdc)	1N5158, 1N5782, 1N5788		–	–	0.1	
(V_S = 6.75 Vdc)	1N5159, 1N5783, 1N5789		–	–	0.1	
(V_S = 7.5 Vdc)	1N5160, 1N5784, 1N5790		–	–	0.1	
(V_S = 8.25 Vdc)	1N5779, 1N5785, 1N5791		–	–	0.1	
(V_S = 9.0 Vdc)	1N5780, 1N5786, 1N5792		–	–	0.1	
(V_S = 9.75 Vdc)	1N5781, 1N5787, 1N5793		–	–	0.1	
Junction Capacitance (AC Voltage = 10 mV, V_F = 0, f = 100 kHz)		C_J	–	45	–	pF
Turn-On Time (Figure 2)		t_{on}	–	75(1)	–	ns
Turn-Off Time (Figure 3)		t_{off}	–	250(1)	–	ns

*Indicates JEDEC Registered Data. (1) Time depends on a wide variety of circuit conditions. Consult manufacturer for further information.

FIGURE 2 – TURN-ON TIME TEST CIRCUIT

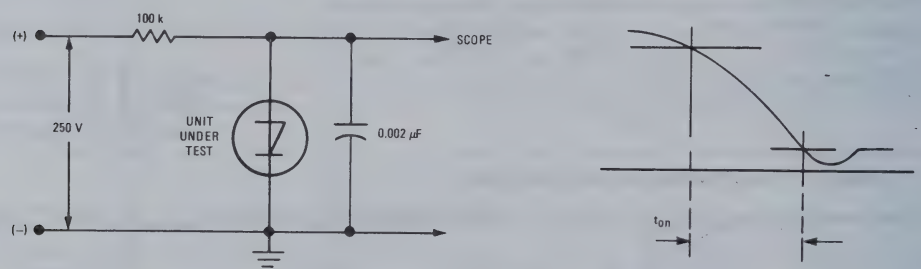


FIGURE 3 – TURN-OFF TIME TEST CIRCUIT

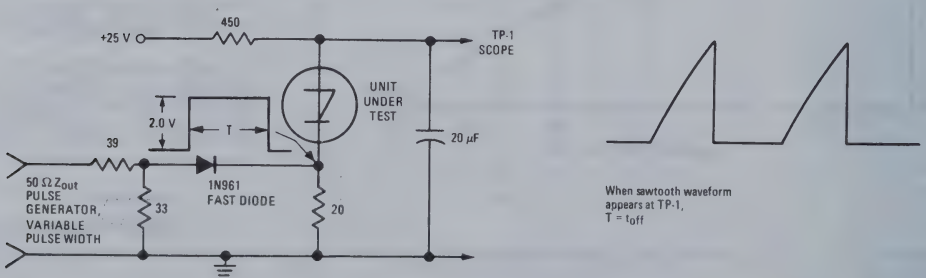


FIGURE 4 – TYPICAL FORWARD CONDUCTION CHARACTERISTICS

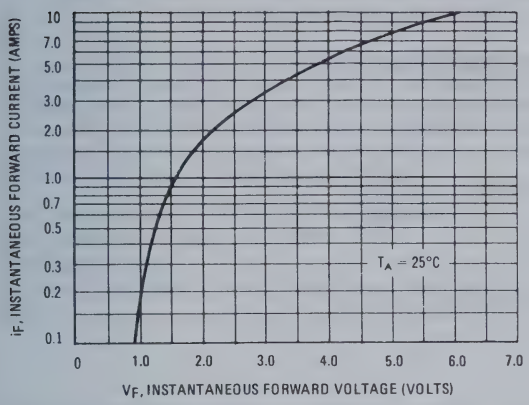
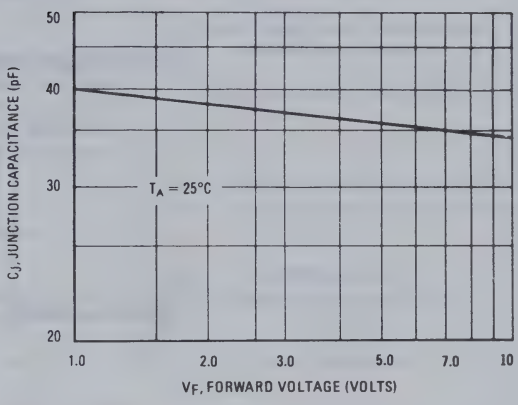


FIGURE 5 – TYPICAL CAPACITANCE



TYPICAL DC CHARACTERISTICS versus TEMPERATURE

(NORMALIZED to 25°C VALUE)

FIGURE 6 – FORWARD BREAKOVER VOLTAGE

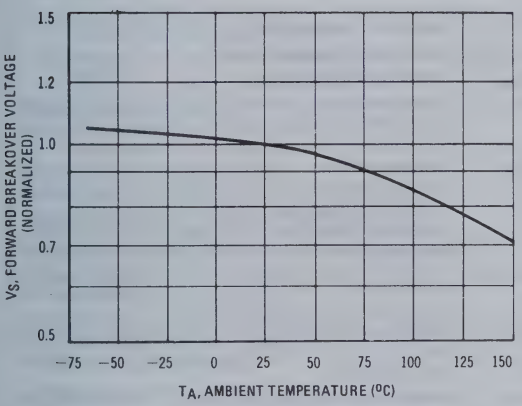


FIGURE 7 – REVERSE BLOCKING VOLTAGE

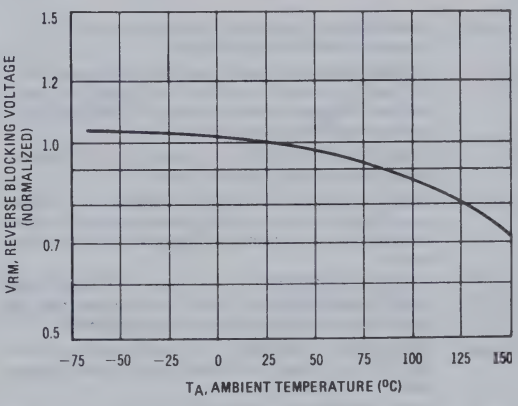


FIGURE 8 – FORWARD BREAKOVER CURRENT

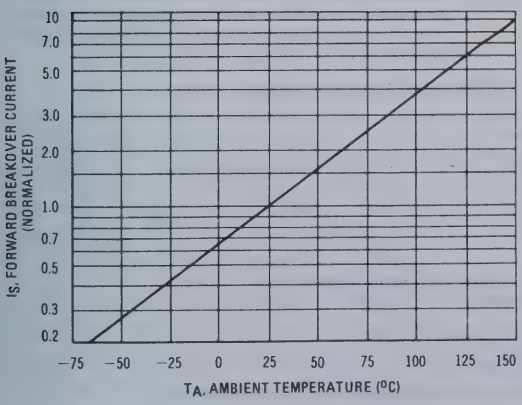
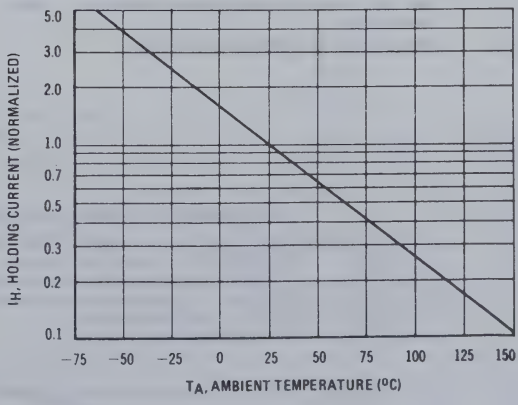
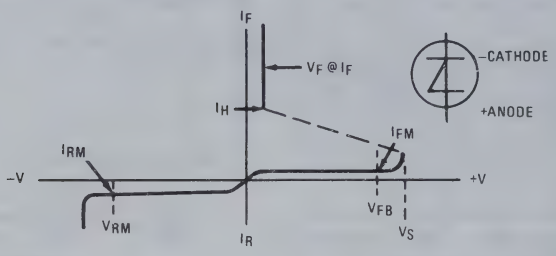


FIGURE 9 – HOLDING CURRENT



4-LAYER DIODE SYMBOLS AND DEFINITIONS



dv/dt **FORWARD VOLTAGE APPLICATION RATE (V/μs)** – The rate of rise of forward voltage.

I_S **FORWARD BREAKOVER (SWITCHING) CURRENT** – The value of anode current at the instant the device switches from the blocking to the "on" state, specified at a particular junction temperature.

I_F **FORWARD CURRENT** – The continuous or DC value of forward current during the "on" state.

I_{FM} **PEAK FORWARD BLOCKING CURRENT** – The peak anode current when the 4-layer diode is in the "off" state for a stated anode-to-cathode voltage and junction temperature.

I_H **HOLDING CURRENT** – That value of forward anode current below which the 4-layer diode switches from the conducting state to the forward blocking condition.

I_{pulse} **PEAK PULSE CURRENT** – The peak repetitive current that can flow through the device for the time duration stated.

I_{RM} **PEAK REVERSE BLOCKING CURRENT** – The peak current when the 4-layer diode is in the reverse blocking state for a stated anode-to-cathode voltage and junction temperature.

P_D **STEADY-STATE POWER DISSIPATION**

T_A **AMBIENT TEMPERATURE**

T_J **JUNCTION TEMPERATURE**

T_{stg} **STORAGE TEMPERATURE**

t_{on} **TURN-ON TIME** – The time interval between the 90% point (90% of forward blocking voltage) and the point 10% above the "on" voltage under stated conditions.

t_{off} **TURN-OFF TIME** – The time interval required for the device to regain control of its forward blocking characteristic after interruption of forward anode current.

V_S **FORWARD BREAKOVER (SWITCHING) VOLTAGE** – The positive anode voltage with respect to cathode required to switch the device from the high impedance blocking state to the low impedance "on" state, specified at a particular junction temperature.

V_F **FORWARD VOLTAGE** – The forward voltage across the device in the "on" state under stated conditions of current and temperature.

V_{FB} **FORWARD BLOCKING VOLTAGE** – The anode-to-cathode voltage when the 4-layer diode is in the "off" state.

V_{RM} **PEAK REVERSE VOLTAGE** – The maximum allowable instantaneous value of reverse voltage (repetitive or continuous DC) which can be applied to the device at a stated temperature without damage to the device.

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed all glass case
DIMENSIONS: JEDEC DO-7 Outline
FINISH: All external surfaces are corrosion resistant with readily solderable leads.
POLARITY: Cathode end indicated by color band.
WEIGHT: 0.2 grams (approx.)
MOUNTING POSITION: Any

1N5221 (SILICON) thru 1N5281 series

500 MILLIWATT SURMETIC▲ 20 SILICON ZENER DIODES (SILICON OXIDE PASSIVATED)

. . .in answer to the Circuit Design and Component Engineers' many requests – A complete new series of Zener Diodes in the popular DO-204AA case with higher ratings, tighter limits, better operating characteristics and a full set of designers' curves that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

- Proven Capability to MIL-S-19500 Specifications
- 10 Watt Surge Rating
- Weldable Leads
- Maximum Limits Guaranteed on Six Electrical Parameters

{ .5M2.4ZS10 thru .5M200ZS10 / 1N5221A thru 1N5281A }

{ .5M2.4ZS5 thru .5M200ZS5 }

500 MILLIWATT ZENER REGULATOR DIODES

2.4 – 200 VOLTS

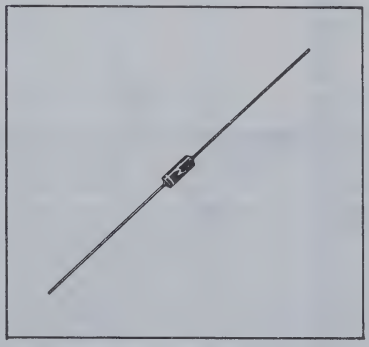
MAXIMUM RATINGS

Junction and Storage Temperature: –65 to +200°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

DC Power Dissipation: 500 mW @ T_L = 75°C, Lead Length = 3/8"
(Derate 4.0 mW/°C above 75°C)

Surge Power: 10 Watts (Non-recurrent square wave @ PW = 8.3 ms, T_J = 55°C, Figure 16)



MECHANICAL CHARACTERISTICS

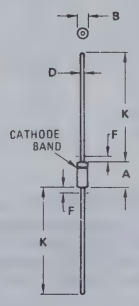
CASE: Void free, transfer molded, thermosetting plastic.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable and weldable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.18 gram (approximately).

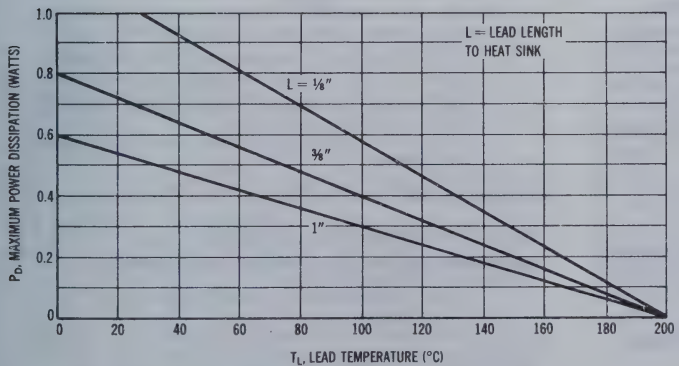


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F		1.27		0.050
K	25.40		1.000	

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



▲Trademark of Motorola Inc.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted). Based on dc measurements at thermal equilibrium; lead length = ⅜"; thermal resistance of heat sink = 30°C/W) **V_F = 1.1 Max @ I_F = 200 mA for all types.**

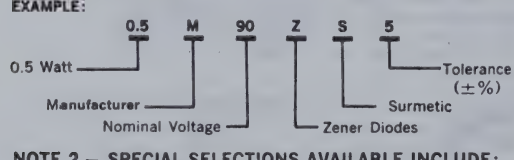
JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current				Max Zener Voltage Temp. Coeff. (A & B Suffix Only) θ_{VZ} (%/°C) (Note 3)
					A & B Suffix Only			Non-Suffix	
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	I_R μA @ V_R Volts			I_R @ V_R Used For Suffix A μA	
						A	B		
1N5221	2.4	20	30	1200	100	0.95	1.0	200	-0.085
1N5222	2.5	20	30	1250	100	0.95	1.0	200	-0.085
1N5223	2.7	20	30	1300	75	0.95	1.0	150	-0.080
1N5224	2.8	20	30	1400	75	0.95	1.0	150	-0.080
1N5225	3.0	20	29	1600	50	0.95	1.0	100	-0.075
1N5226	3.3	20	28	1600	25	0.95	1.0	100	-0.070
1N5227	3.6	20	24	1700	15	0.95	1.0	100	-0.065
1N5228	3.9	20	23	1900	10	0.95	1.0	75	-0.060
1N5229	4.3	20	22	2000	5.0	0.95	1.0	50	±0.055
1N5230	4.7	20	19	1900	5.0	1.9	2.0	50	±0.030
1N5231	5.1	20	17	1600	5.0	1.9	2.0	50	±0.030
1N5232	5.6	20	11	1600	5.0	2.9	3.0	50	+0.038
1N5233	6.0	20	7.0	1600	5.0	3.3	3.5	50	+0.038
1N5234	6.2	20	7.0	1000	5.0	3.8	4.0	50	+0.045
1N5235	6.8	20	5.0	750	3.0	4.8	5.0	30	+0.050
1N5236	7.5	20	6.0	500	3.0	5.7	6.0	30	+0.058
1N5237	8.2	20	8.0	500	3.0	6.2	6.5	30	+0.062
1N5238	8.7	20	8.0	600	3.0	6.2	6.5	30	+0.065
1N5239	9.1	20	10	600	3.0	6.7	7.0	30	+0.068
1N5240	10	20	17	600	3.0	7.6	8.0	30	+0.075
1N5241	11	20	22	600	2.0	8.0	8.4	30	+0.076
1N5242	12	20	30	600	1.0	8.7	9.1	10	+0.077
1N5243	13	9.5	13	600	0.5	9.4	9.9	10	+0.079
1N5244	14	9.0	15	600	0.1	9.5	10	10	+0.082
1N5245	15	8.5	16	600	0.1	10.5	11	10	+0.082
1N5246	16	7.8	17	600	0.1	11.4	12	10	+0.083
1N5247	17	7.4	19	600	0.1	12.4	13	10	+0.084
1N5248	18	7.0	21	600	0.1	13.3	14	10	+0.085
1N5249	19	6.6	23	600	0.1	13.3	14	10	+0.086
1N5250	20	6.2	25	600	0.1	14.3	15	10	+0.086
1N5251	22	5.6	29	600	0.1	16.2	17	10	+0.087
1N5252	24	5.2	33	600	0.1	17.1	18	10	+0.088
1N5253	25	5.0	35	600	0.1	18.1	19	10	+0.089
1N5254	27	4.6	41	600	0.1	20	21	10	+0.090
1N5255	28	4.5	44	600	0.1	20	21	10	+0.091
1N5256	30	4.2	49	600	0.1	22	23	10	+0.091
1N5257	33	3.8	58	700	0.1	24	25	10	+0.092
1N5258	36	3.4	70	700	0.1	26	27	10	+0.093
1N5259	39	3.2	80	800	0.1	29	30	10	+0.094
1N5260	43	3.0	93	900	0.1	31	33	10	+0.095
1N5261	47	2.7	105	1000	0.1	34	36	10	+0.095
1N5262	51	2.5	125	1100	0.1	37	39	10	+0.096
1N5263	56	2.2	150	1300	0.1	41	43	10	+0.096
1N5264	60	2.1	170	1400	0.1	44	46	10	+0.097
1N5265	62	2.0	185	1400	0.1	45	47	10	+0.097
1N5266	68	1.8	230	1600	0.1	49	52	10	+0.097
1N5267	75	1.7	270	1700	0.1	53	56	10	+0.098
1N5268	82	1.5	330	2000	0.1	59	62	10	+0.098
1N5269	87	1.4	370	2200	0.1	65	68	10	+0.099
1N5270	91	1.4	400	2300	0.1	66	69	10	+0.099
1N5271	100	1.3	500	2600	0.1	72	76	10	+0.110
1N5272	110	1.1	750	3000	0.1	80	84	10	+0.110
1N5273	120	1.0	900	4000	0.1	86	91	10	+0.110
1N5274	130	0.95	1100	4500	0.1	94	99	10	+0.110
1N5275	140	0.90	1300	4500	0.1	101	106	10	+0.110
1N5276	150	0.85	1500	5000	0.1	108	114	10	+0.110
1N5277	160	0.80	1700	5500	0.1	116	122	10	+0.110
1N5278	170	0.74	1900	5500	0.1	123	129	10	+0.110
1N5279	180	0.68	2200	6000	0.1	130	137	10	+0.110
1N5280	190	0.66	2400	6500	0.1	137	144	10	+0.110
1N5281	200	0.65	2500	7000	0.1	144	152	10	+0.110

NOTE 1 — TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R and V_F as shown in the above table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.

Non-Standard voltage designation — To designate units with zener voltages other than those assigned JEDEC numbers, the type number should be used.

EXAMPLE:



NOTE 2 — SPECIAL SELECTIONS AVAILABLE INCLUDE:

1 — Nominal zener voltages between those shown.

2 — **Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.**

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

NOTE 3 — TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

a. I_{ZT} = 7.5 mA, T_1 = 25°C,
T_2 = 125°C (1N5221A, B thru 1N5242A, B.)

b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C,
T_2 = 125°C (1N5243A, B thru 1N5281A, B.)

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

TYPICAL REVERSE CHARACTERISTICS FOR SELECTED ZENER DIODES

Curves marked T_A were obtained from dc measurements at thermal equilibrium; lead length = ⅜"; thermal resistance of heat sink = 30°C/W.
Curves marked T_J were obtained from pulse tests; mounting conditions are not a factor.

$V_{Z(Nominal)} = 3.3$ Volts

FIGURE 2

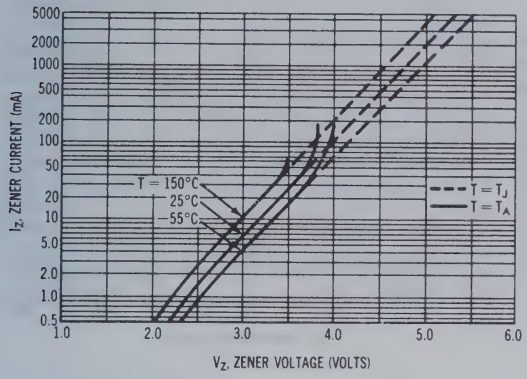
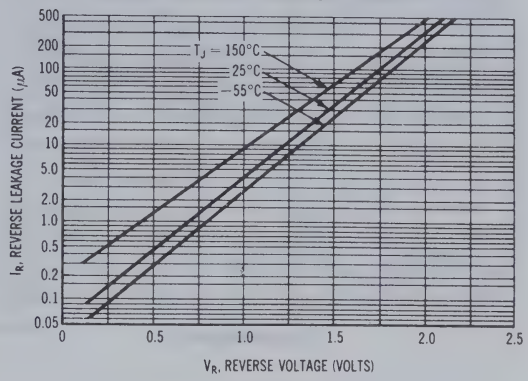


FIGURE 3



$V_{Z(Nominal)} = 5.1$ Volts

FIGURE 4

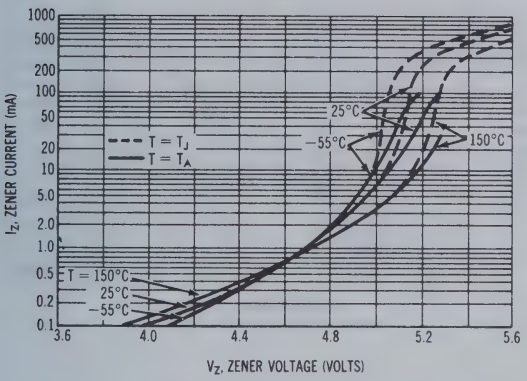
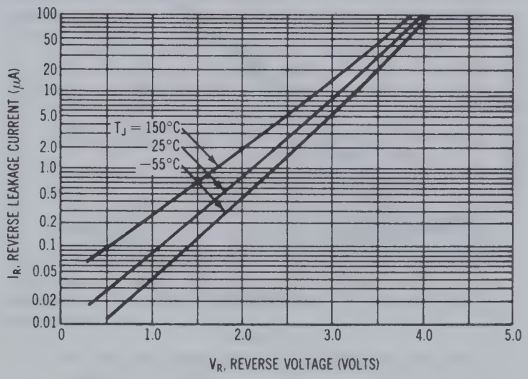


FIGURE 5



$V_{Z(Nominal)} = 27$ Volts

FIGURE 6

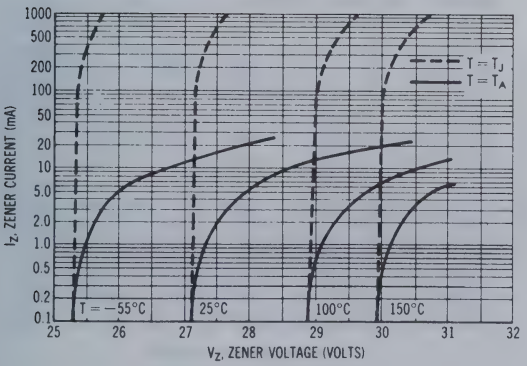
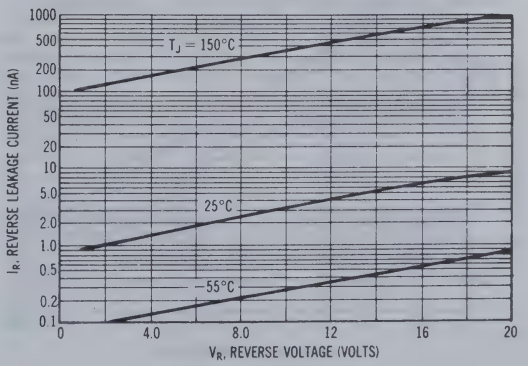


FIGURE 7



TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% of the units are in the ranges indicated)

FIGURE 8 — RANGE FOR UNITS TO 12 VOLTS

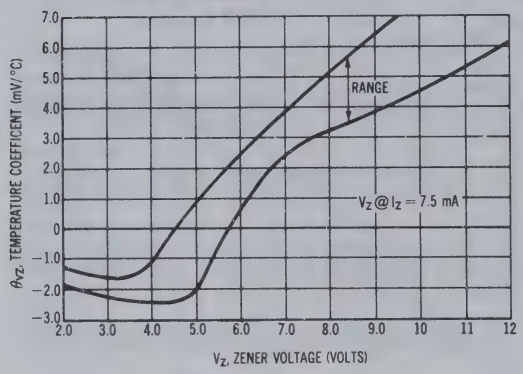


FIGURE 9 — RANGE FOR UNITS 12 TO 200 VOLTS

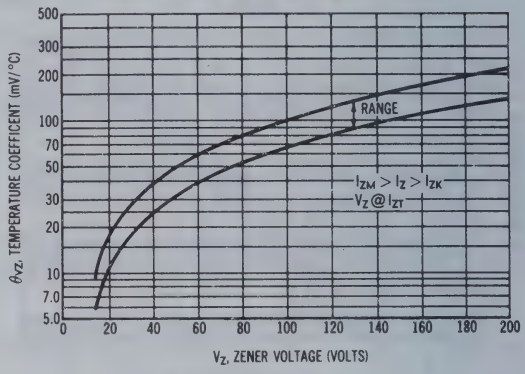


FIGURE 10 — EFFECT OF ZENER CURRENT

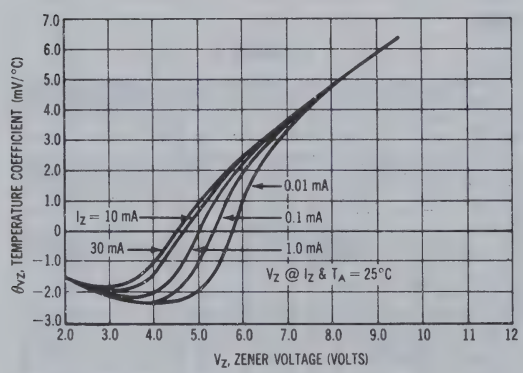
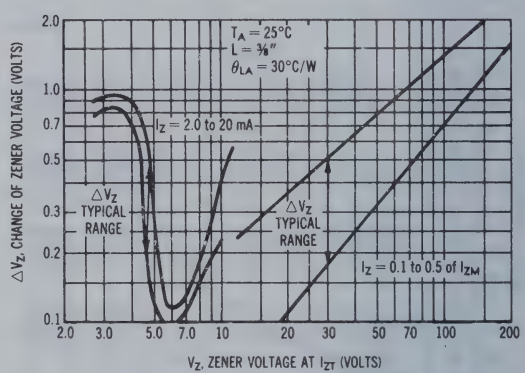


FIGURE 11 — VOLTAGE REGULATION



TYPICAL ZENER IMPEDANCE

FIGURE 12 — EFFECT OF ZENER CURRENT

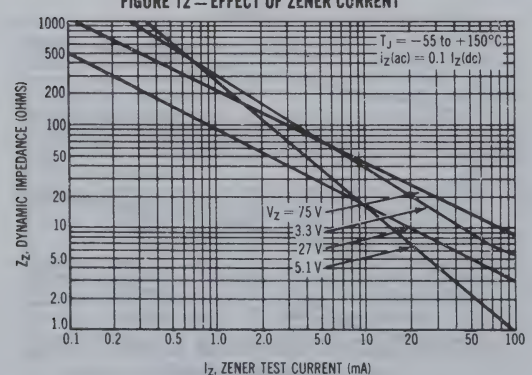


FIGURE 13 — EFFECT OF ZENER VOLTAGE

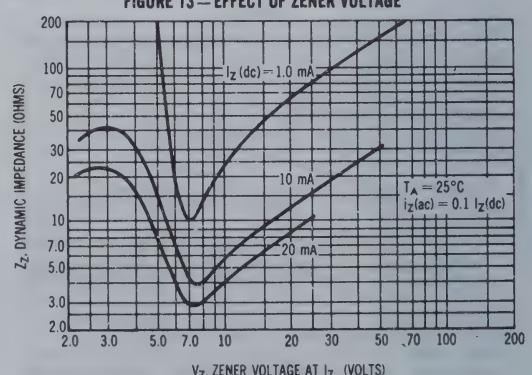


FIGURE 14 — TYPICAL THERMAL RESPONSE

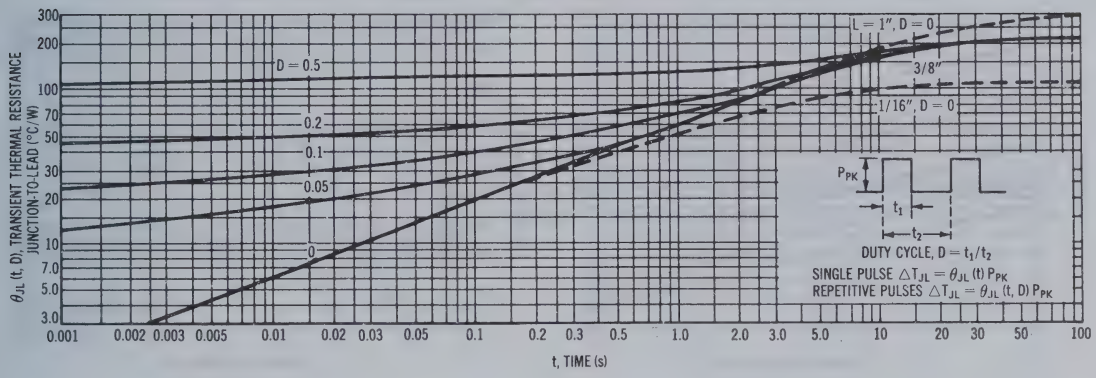


FIGURE 15 — TYPICAL THERMAL RESISTANCE

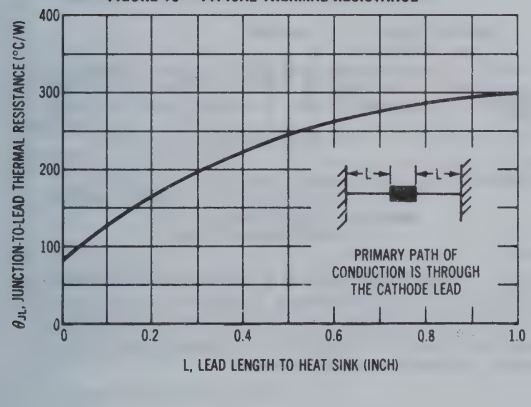
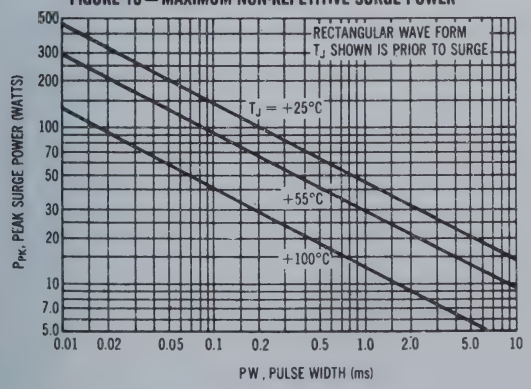


FIGURE 16 — MAXIMUM NON-REPETITIVE SURGE POWER



APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions, in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance and P_D is the power dissipation. θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use and for printed circuit board wiring.

Junction Temperature, T_J, may be found from:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 14 for a train of power pulses or from Figure 15 for dc power.

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of T_J (ΔT_J) may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 8, 9, and 10.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, use short leads, especially to the cathode, and keep current excursions as low as possible.

Data of Figure 14 should not be used to compute surge capability. Surge limitations are given in Figure 16. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 16 be exceeded.

FIGURE 17 — TYPICAL CAPACITANCE

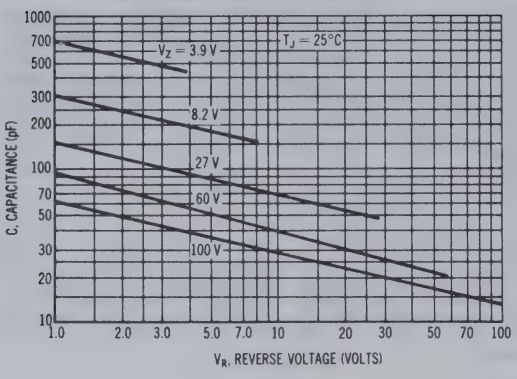


FIGURE 18 — TYPICAL FORWARD CHARACTERISTICS

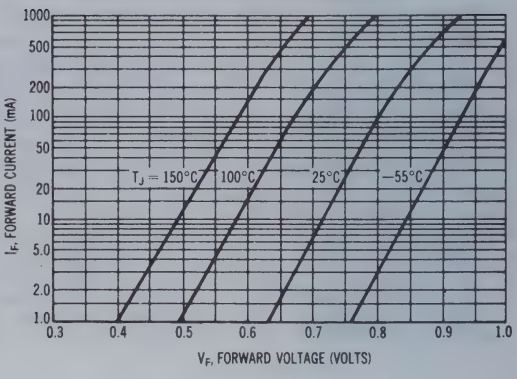


FIGURE 19 — TYPICAL NOISE DENSITY

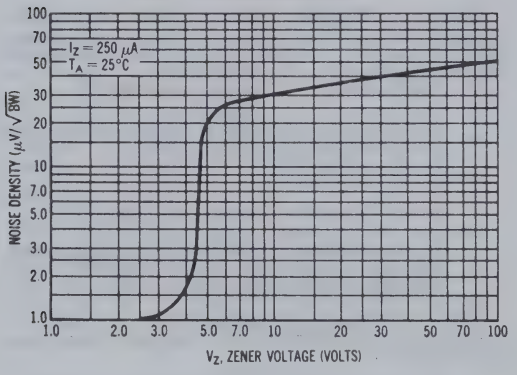
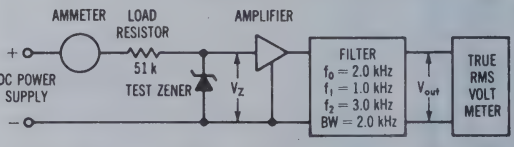


FIGURE 20 — NOISE DENSITY MEASUREMENT METHOD



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH)} = \frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test zener. The filter bandpass is known so that the noise density can be calculated from the formula shown. The data of Figure 19 and the formula can also be used to find noise for any system bandwidth.

1N5283 thru 1N5314



CASE 51
(DO-7)

Field-effect current regulator diodes are circuit elements that provide a current essentially independent of voltage. These diodes are especially designed for maximum impedance over the operating range. These devices may be used in parallel to obtain higher currents.

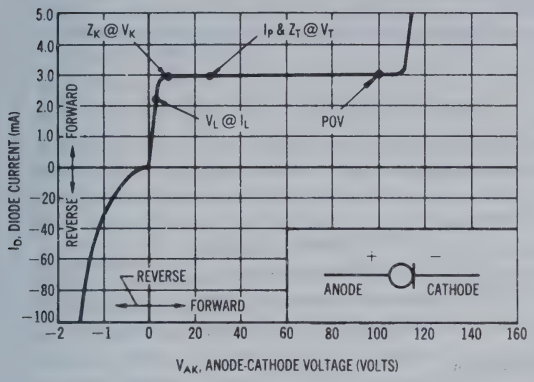
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Operating Voltage (T_J = -55° C to +200° C)	POV	100	Volts
Steady State Power Dissipation @ T_L = 75° C	P_D	600	mW
Derate above T_L = 75° C		4.8	mW/° C
Lead Length = 3/8" (Forward or Reverse Bias)			
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	° C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Type No.	Regulator Current I_P (mA) @ V_T = 25 V nom	min	max	Minimum Dynamic Impedance @V_T = 25 V Z_T (MΩ)	Minimum Knee Impedance @V_K = 6.0 V Z_K (MΩ)	Maximum Limiting Voltage @I_L = 0.8 I_P (min) V_L (Volts)
1N5283	0.22	0.198	0.242	25.0	2.75	1.00
1N5284	0.24	0.216	0.264	19.0	2.35	1.00
1N5285	0.27	0.243	0.297	14.0	1.95	1.00
1N5286	0.30	0.270	0.330	9.0	1.60	1.00
1N5287	0.33	0.297	0.363	6.6	1.35	1.00
1N5288	0.39	0.351	0.429	4.10	1.00	1.05
1N5289	0.43	0.387	0.473	3.30	0.870	1.05
1N5290	0.47	0.423	0.517	2.70	0.750	1.05
1N5291	0.56	0.504	0.616	1.90	0.560	1.10
1N5292	0.62	0.558	0.682	1.55	0.470	1.13
1N5293	0.68	0.612	0.748	1.35	0.400	1.15
1N5294	0.75	0.675	0.825	1.15	0.335	1.20
1N5295	0.82	0.738	0.902	1.00	0.290	1.25
1N5296	0.91	0.819	1.001	0.880	0.240	1.29
1N5297	1.00	0.900	1.100	0.800	0.205	1.35
1N5298	1.10	0.990	1.210	0.700	0.180	1.40
1N5299	1.20	1.08	1.32	0.640	0.155	1.45
1N5300	1.30	1.17	1.43	0.580	0.135	1.50
1N5301	1.40	1.26	1.54	0.540	0.115	1.55
1N5302	1.50	1.35	1.65	0.510	0.105	1.60
1N5303	1.60	1.44	1.76	0.475	0.092	1.65
1N5304	1.80	1.62	1.98	0.420	0.074	1.75
1N5305	2.00	1.80	2.20	0.395	0.061	1.85
1N5306	2.20	1.98	2.42	0.370	0.052	1.95
1N5307	2.40	2.16	2.64	0.345	0.044	2.00
1N5308	2.70	2.43	2.97	0.320	0.035	2.15
1N5309	3.00	2.70	3.30	0.300	0.029	2.25
1N5310	3.30	2.97	3.63	0.280	0.024	2.35
1N5311	3.60	3.24	3.96	0.265	0.020	2.50
1N5312	3.90	3.51	4.29	0.255	0.017	2.60
1N5313	4.30	3.87	4.73	0.245	0.014	2.75
1N5314	4.70	4.23	5.17	0.235	0.012	2.90

FIGURE 1 — TYPICAL CURRENT REGULATOR CHARACTERISTICS



SYMBOLS AND DEFINITIONS

I_D — Diode Current.

I_L — Limiting Current: 80% of I_P minimum used to determine Limiting voltage, V_L.

I_P — Pinch-off Current: Regulator current at specified Test Voltage, V_T.

POV — Peak Operating Voltage: Maximum voltage to be applied to device.

θ_I — Current Temperature Coefficient.

V_{AK} — Anode-to-cathode Voltage.

V_K — Knee Impedance Test Voltage: Specified voltage used to establish Knee Impedance, Z_K.

V_L — Limiting Voltage: Measured at I_L. V_L, together with Knee AC Impedance, Z_K, indicates the Knee characteristics of the device.

V_T — Test Voltage: Voltage at which I_P and Z_T are specified.

Z_K — Knee AC Impedance at Test Voltage: To test for Z_K, a 90 Hz signal v_K with RMS value equal to 10% of test voltage, V_K, is superimposed on V_K:

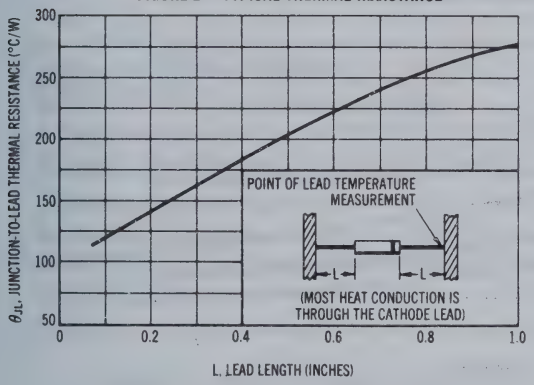
$$Z_K = v_K / i_K$$

where i_K is the resultant ac current due to v_K

To provide the most constant current from the diode, Z_K should be as high as possible; therefore, a minimum value of Z_K is specified.

Z_T — AC Impedance at Test Voltage: Specified as a minimum value. To test for Z_T, a 90 Hz signal with RMS value equal to 10% of Test Voltage, V_T, is superimposed on V_T.

FIGURE 2 — TYPICAL THERMAL RESISTANCE



APPLICATION NOTE

As the current available from the diode is temperature dependent, it is necessary to determine junction temperature, T_J, under specific operating conditions to calculate the value of the diode current. The following procedure is recommended:

Lead Temperature, T_L, shall be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

where θ_{LA} is lead-to-ambient thermal resistance

and P_D is power dissipation.

θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use, and for printed circuit-board wiring.

Junction Temperature, T_J, shall be calculated from:

$$T_J = T_L + \theta_{JL} P_D$$

where θ_{JL} is taken from Figure 2.

For circuit design limits of V_{AK}, limits of P_D may be estimated and extremes of T_J may be computed. Using the information on Figures 4 and 5, changes in current may be found. To improve current regulation, keep V_{AK} low to reduce P_D and keep the leads short, especially the cathode lead, to reduce θ_{JL}.

FIGURE 3 — TYPICAL FORWARD CHARACTERISTICS

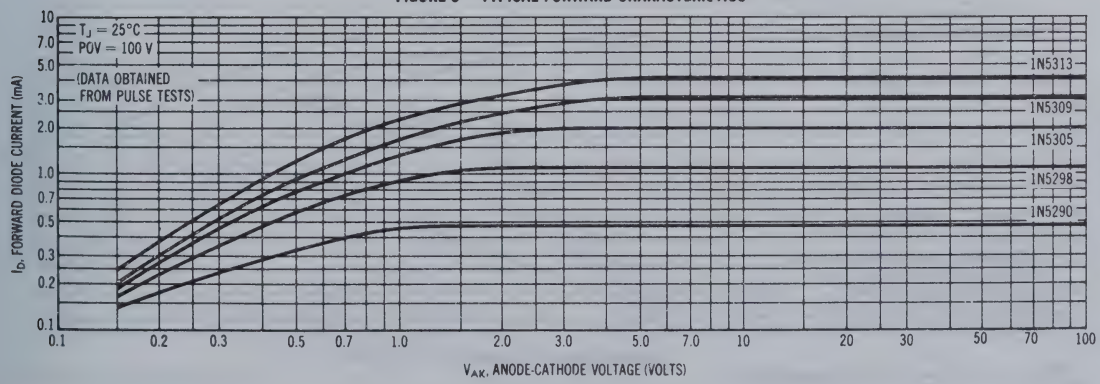


FIGURE 4 — TEMPERATURE COEFFICIENT

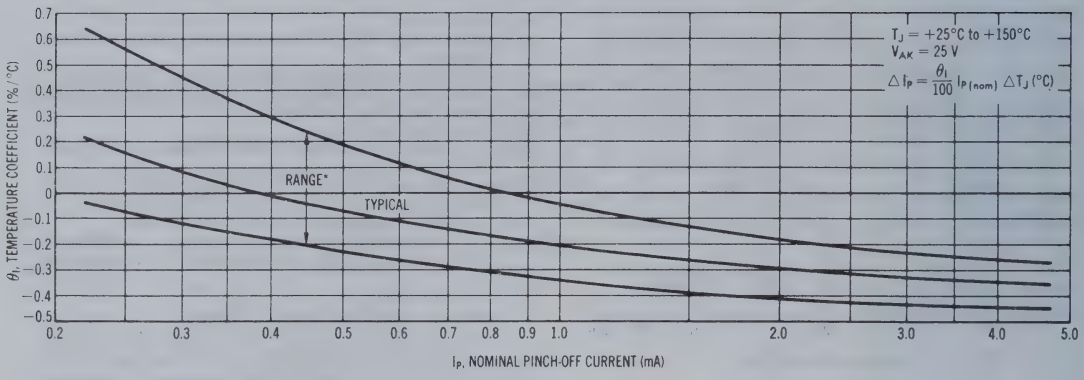


FIGURE 5 — TEMPERATURE COEFFICIENT

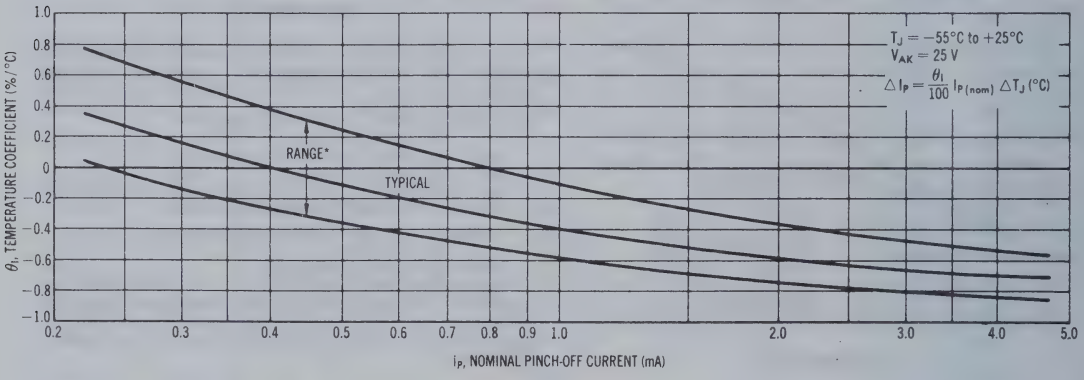
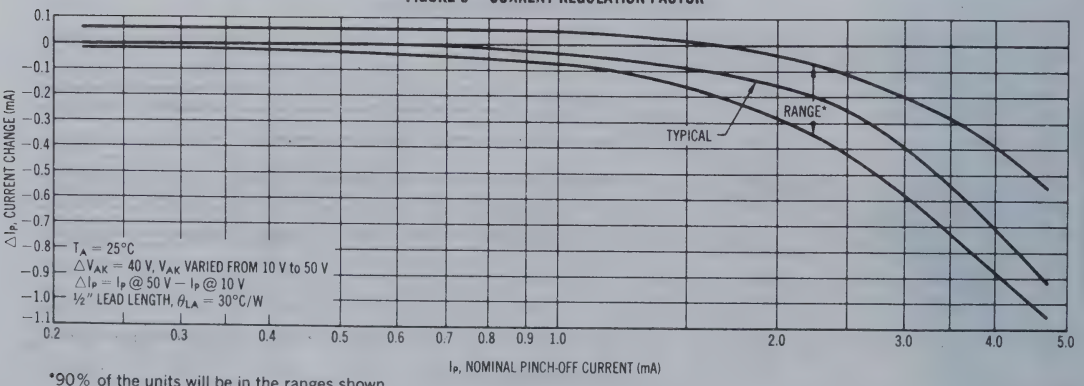


FIGURE 6 — CURRENT REGULATION FACTOR



*90% of the units will be in the ranges shown.

1N5333 (SILICON) thru 1N5388

5.0 WATT SURMETIC▲ 40 SILICON ZENER DIODES (SILICON OXIDE PASSIVATED)

. . . a complete new series of 5.0 Watt Zener Diodes with tight limits and better operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

- Up to 180 Watt Surge Rating @ 8.3 ms
- Maximum Limits Guaranteed on Seven Electrical Parameters

(5M3.3ZS10 thru 5M200ZS10
1N5333A thru 1N5388A)
(5M3.3ZS5 thru 5M200ZS5
1N5333B thru 1N5388B)

5.0 WATT
ZENER REGULATOR DIODES

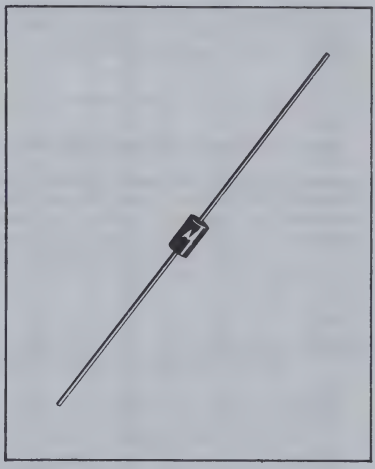
3.3 – 200 VOLTS

MAXIMUM RATINGS

Junction and Storage Temperature: −65 to +200°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

DC Power Dissipation: 5.0 W @ T_L = 75°C, Lead Length = 3/8"
(Derate 40 mW/°C above 75°C)



MECHANICAL CHARACTERISTICS

CASE: Void-free, transfer-molded, thermosetting plastic

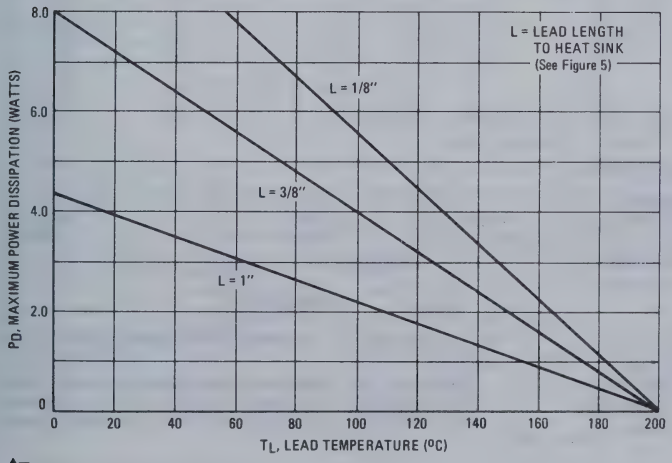
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable

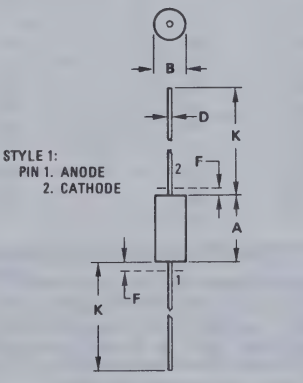
POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any

WEIGHT: 0.7 gram (approx)

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.38	8.89	0.330	0.350
B	3.30	3.68	0.130	0.145
D	0.94	1.09	0.037	0.043
F	–	1.27	–	0.050
K	25.40	31.75	1.000	1.250

CASE 17

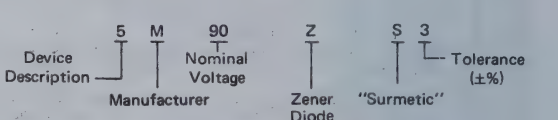
▲Trademark of Motorola Inc.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) V_F = 1.2 Max @ I_F = 1.0 A for all types

JEDEC Type No. (Note 1 & 2)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 3)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current			Applies to all Suffix	A & B Suffix Only	Maximum Regulator Current I_{ZM} mA
			Z_{ZT} @ I_{ZT} Ohms (Note 3)	Z_{ZK} @ i_{ZK} = 1.0 mA Ohms (Note 3)	I_R μA	@ V_R Volts		Max Surge Current i_r, Amps	Max Voltage Regulation ΔV_Z, Volts	
						Non & A Suffix	B-Suffix	(Note 4)	(Note 5)	(Note 6)
1N5333	3.3	380	3.0	400	300	1.0	1.0	20.0	0.85	1440
1N5334	3.6	350	2.5	500	150	1.0	1.0	18.7	0.80	1320
1N5335	3.9	320	2.0	500	50	1.0	1.0	17.6	0.54	1220
1N5336	4.3	290	2.0	500	10	1.0	1.0	16.4	0.49	1100
1N5337	4.7	260	2.0	450	5.0	1.0	1.0	15.3	0.44	1010
1N5338	5.1	240	1.5	400	1.0	1.0	1.0	14.4	0.39	930
1N5339	5.6	220	1.0	400	1.0	2.0	2.0	13.4	0.25	865
1N5340	6.0	200	1.0	300	1.0	3.0	3.0	12.7	0.19	790
1N5341	6.2	200	1.0	200	1.0	3.0	3.0	12.4	0.10	765
1N5342	6.8	175	1.0	200	10	4.9	5.2	11.5	0.15	700
1N5343	7.5	175	1.5	200	10	5.4	5.7	10.7	0.15	630
1N5344	8.2	150	1.5	200	10	5.9	6.2	10.0	0.20	580
1N5345	8.7	150	2.0	200	10	6.3	6.6	9.5	0.20	545
1N5346	9.1	150	2.0	150	7.5	6.6	6.9	9.2	0.22	520
1N5347	10	125	2.0	125	5.0	7.2	7.6	8.6	0.22	475
1N5348	11	125	2.5	125	5.0	8.0	8.4	8.0	0.25	430
1N5349	12	100	2.5	125	2.0	8.6	9.1	7.5	0.25	395
1N5350	13	100	2.5	100	1.0	9.4	9.9	7.0	0.25	365
1N5351	14	100	2.5	75	1.0	10.1	10.6	6.7	0.25	340
1N5352	15	75	2.5	75	1.0	10.8	11.5	6.3	0.25	315
1N5353	16	75	2.5	75	1.0	11.5	12.2	6.0	0.30	295
1N5354	17	70	2.5	75	0.5	12.2	12.9	5.8	0.35	280
1N5355	18	65	2.5	75	0.5	13.0	13.7	5.5	0.40	264
1N5356	19	65	3.0	75	0.5	13.7	14.4	5.3	0.40	250
1N5357	20	65	3.0	75	0.5	14.4	15.2	5.1	0.40	237
1N5358	22	50	3.5	75	0.5	15.8	16.7	4.7	0.45	216
1N5359	24	50	3.5	100	0.5	17.3	18.2	4.4	0.55	198
1N5360	25	50	4.0	110	0.5	18.0	19.0	4.3	0.55	190
1N5361	27	50	5.0	120	0.5	19.4	20.6	4.1	0.60	176
1N5362	28	50	6.0	130	0.5	20.1	21.2	3.9	0.60	170
1N5363	30	40	8.0	140	0.5	21.6	22.8	3.7	0.60	158
1N5364	33	40	10	150	0.5	23.8	25.1	3.5	0.60	144
1N5365	36	30	11	160	0.5	25.9	27.4	3.3	0.65	132
1N5366	39	30	14	170	0.5	28.1	29.7	3.1	0.65	122
1N5367	43	30	20	190	0.5	31.0	32.7	2.8	0.70	110
1N5368	47	25	25	210	0.5	33.8	35.8	2.7	0.80	100
1N5369	51	25	27	230	0.5	36.7	38.8	2.5	0.90	93.0
1N5370	56	20	35	280	0.5	40.3	42.6	2.3	1.00	86.0
1N5371	60	20	40	350	0.5	43.0	45.5	2.2	1.20	79.0
1N5372	62	20	42	400	0.5	44.6	47.1	2.1	1.35	76.0
1N5373	68	20	44	500	0.5	49.0	51.7	2.0	1.50	70.0
1N5374	75	20	45	620	0.5	54.0	56.0	1.9	1.60	63.0
1N5375	82	15	65	720	0.5	59.0	62.2	1.8	1.80	58.0
1N5376	87	15	75	760	0.5	63.0	66.0	1.7	2.00	54.5
1N5377	91	15	75	760	0.5	65.5	69.2	1.6	2.20	52.5
1N5378	100	12	90	800	0.5	72.0	76.0	1.5	2.50	47.5
1N5379	110	12	125	1000	0.5	79.2	83.6	1.4	2.50	43.0
1N5380	120	10	170	1150	0.5	86.4	91.2	1.3	2.50	39.5
1N5381	130	10	190	1250	0.5	93.6	98.8	1.2	2.50	36.6
1N5382	140	8.0	230	1500	0.5	101	106	1.2	2.50	34.0
1N5383	150	8.0	330	1500	0.5	108	114	1.1	3.00	31.6
1N5384	160	8.0	350	1650	0.5	115	122	1.1	3.00	29.4
1N5385	170	8.0	380	1750	0.5	122	129	1.0	3.00	28.0
1N5386	180	5.0	430	1750	0.5	130	137	1.0	4.00	26.4
1N5387	190	5.0	450	1850	0.5	137	144	0.9	5.00	25.0
1N5388	200	5.0	480	1850	0.5	144	152	0.9	5.00	23.6

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

TOLERANCE DESIGNATION – The JEDEC type numbers shown indicate a tolerance of ±20% with guaranteed limits on only V_Z, I_R, i_r, and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all seven parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.



Example: **5M90ZS3**

NOTE 2 – SPECIALS AVAILABLE INCLUDE:

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES: To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Mfg. type number should be used.

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units

with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.

5	M	5 1	Z	S	5	B	1
Device Description	Manufacturer	51 Volts (each device)	Zener Diodes	"Surmetic"	Tolerance per device (±5%) (omit for ±20% units)	Code* (A-Not used)	Overall Tolerance of set (±1%)

*Code:
B – Two devices in series
C – Three devices in series
D – Four devices in series

Example: **5M51ZS5B1**

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

5	M	20,	Z	Z	10
Device Description	Manufacturer	Nominal Voltage	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: **5M20ZZ10**

NOTE 3 – ZENER VOLTAGE (V_Z) AND IMPEDANCE (Z_{ZT} & Z_{ZK})

Test conditions for Zener voltage and impedance are as follows: I_Z is applied 40 ± 10 ms prior to reading. Mounting contacts are located 3/8" to 1/2" from the inside edge of mounting clips to the body of the diode. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$).

NOTE 4 – SURGE CURRENT (i_r)

Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a pulse width, PW, of 8.3 ms. The data given in Figure 6 may be used to find the maximum surge current for a square wave of any pulse width between 1.0 ms and 1000 ms by plotting the applicable points on logarithmic paper. Examples of this, using the 3.3 V and 200 V zeners, are shown in Figure 7. Mounting contact located as specified in Note 3. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$).

NOTE 5 – VOLTAGE REGULATION (ΔV_Z)

Test conditions for voltage regulation are as follows: V_Z measurements are made at 10% and then at 50% of the I_Z max value listed in the electrical characteristics table. The test currents are the same for the 5% and 10% tolerance devices. The test current time duration for each V_Z measurement is 40 ± 10 ms. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$). Mounting contact located as specified in Note 3.

NOTE 6 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5% type unit, therefore, it applies only to the B-suffix device. The actual I_{ZM} for any device may not exceed the value of 5.0 watts divided by the actual V_Z of the device. $T_L = 75^oC$ at 3/8" maximum from the device body.

TEMPERATURE COEFFICIENTS

FIGURE 2 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 3.0 TO 10 VOLTS

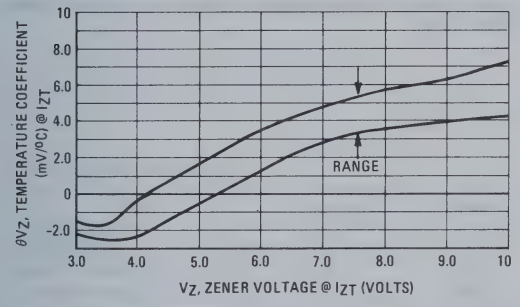


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

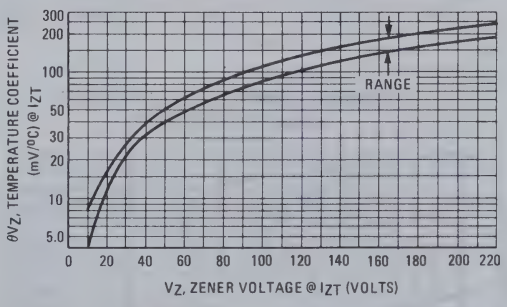


FIGURE 4 – TYPICAL THERMAL RESPONSE

L, LEAD LENGTH = 3/8 INCH

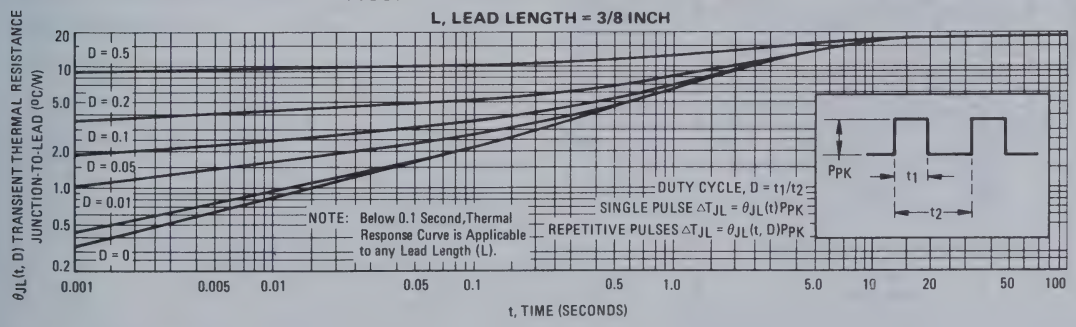


FIGURE 5 – TYPICAL THERMAL RESISTANCE

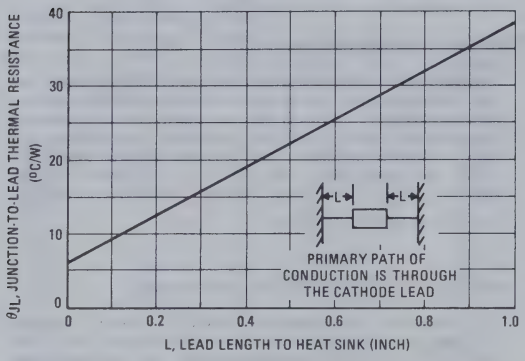


FIGURE 6 – MAXIMUM NON-REPETITIVE SURGE CURRENT versus NOMINAL ZENER VOLTAGE
(See Note 4)

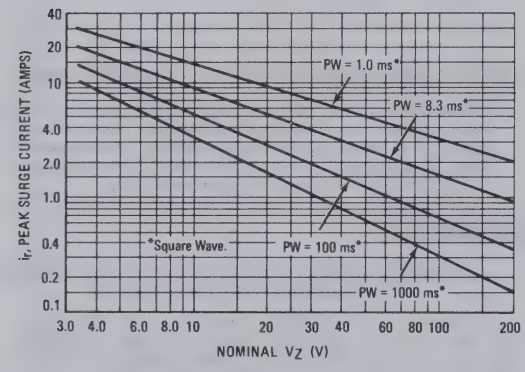
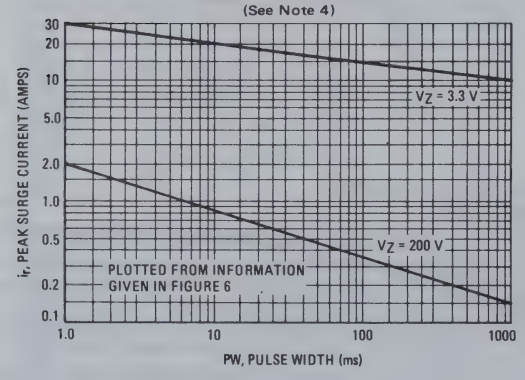


FIGURE 7 – PEAK SURGE CURRENT versus PULSE WIDTH
(See Note 4)



APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions, in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance and P_D is the power dissipation.

Junction Temperature, T_J, may be found from:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 4 for a train of power pulses or from Figure 5 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of $T_J(\Delta T_J)$ may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 2 and 3.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 4 should not be used to compute surge capability. Surge limitations are given in Figure 6. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 6 be exceeded.

1N5441A,B,C (SILICON) thru 1N5456A,B,C

VVC

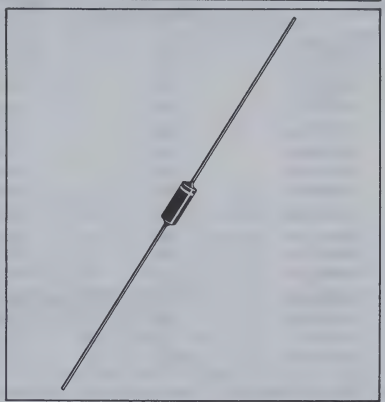
SILICON EPICAP DIODES

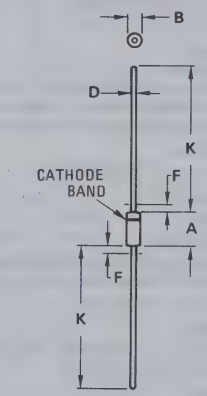
. . . epitaxial passivated abrupt junction tuning diodes designed for electronic tuning, FM, AFC and harmonic-generation applications in AM through UHF ranges, providing solid-state reliability to replace mechanical tuning methods.

- Excellent Q Factor at High Frequencies
- Guaranteed Capacitance Change — 2.0 to 30 V
- Guaranteed Temperature Coefficient
- Capacitance Tolerance — 10%, 5.0%, and 2.0%
- Complete Typical Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8 – 100 pF
30 VOLTS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

**** MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

****Indicates JEDEC Registered Data.**

**ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 25 Vdc, T_A = 25°C V_R = 25 Vdc, T_A = 150°C	I_R	– –	– –	0.02 20	μAdc
Series Inductance	f = 250 MHz, lead length≈1/16"	L_S	–	4.0	10	nH
Case Capacitance	f = 1.0 MHz, lead length≈1/16"	C_C	0.1	0.17	0.25	pF
Diode Capacitance Temperature Coefficient (Note 6)	V_R = 4.0 Vdc, f = 1.0 MHz	TC_C	–	300	400	ppm/°C

Device	C_T, Diode Capacitance* V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom -10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5441A	6.1	6.8	7.5	2.5	3.1	450
1N5442A	7.4	8.2	9.0	2.5	3.1	450
1N5443A	9.0	10.0	11.0	2.6	3.1	400
1N5444A	10.8	12.0	13.2	2.6	3.1	400
1N5445A	13.5	15.0	16.5	2.6	3.1	400
1N5446A	16.2	18.0	19.8	2.6	3.1	350
1N5447A	18.0	20.0	22.0	2.6	3.1	350
1N5448A	19.8	22.0	24.2	2.6	3.2	350
1N5449A	24.3	27.0	29.7	2.6	3.2	350
1N5450A	29.7	33.0	36.3	2.6	3.2	350
1N5451A	35.1	39.0	42.9	2.6	3.2	300
1N5452A	42.3	47.0	51.7	2.6	3.2	250
1N5453A	50.4	56.0	61.6	2.6	3.3	200
1N5454A	61.2	68.0	74.8	2.7	3.3	175
1N5455A	73.8	82.0	90.2	2.7	3.3	175
1N5456A	90.0	100.0	110.0	2.7	3.3	175

*To order devices with C_T Nom ±5.0% or ±2.0% add Suffix B or C respectively.

**Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **TR, Tuning Ratio**
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

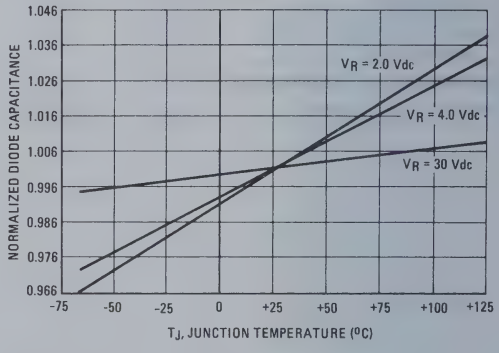
(Boonton Electronics Model 33AS8 or equivalent).

6. **TC_C, Diode Capacitance Temperature Coefficient**
   TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 – DIODE CAPACITANCE versus REVERSE VOLTAGE

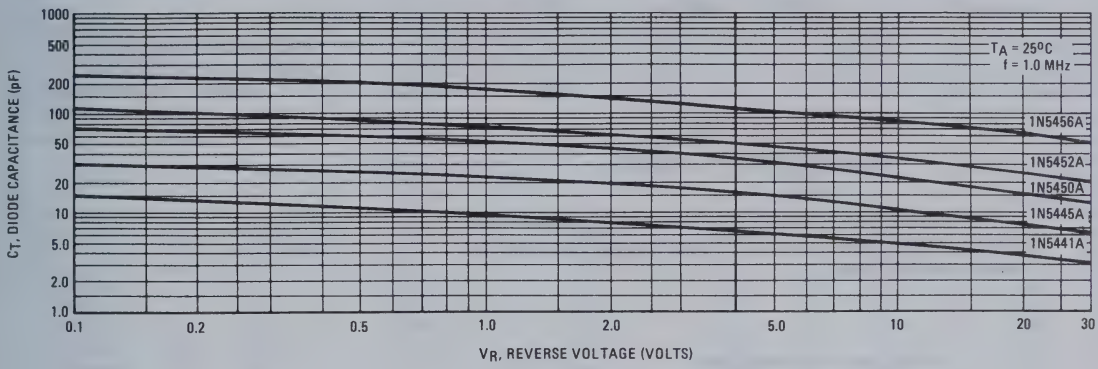


FIGURE 3 – FIGURE OF MERIT versus REVERSE VOLTAGE

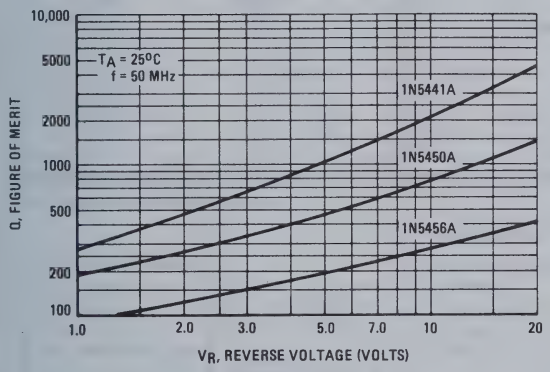


FIGURE 4 – FIGURE OF MERIT versus FREQUENCY

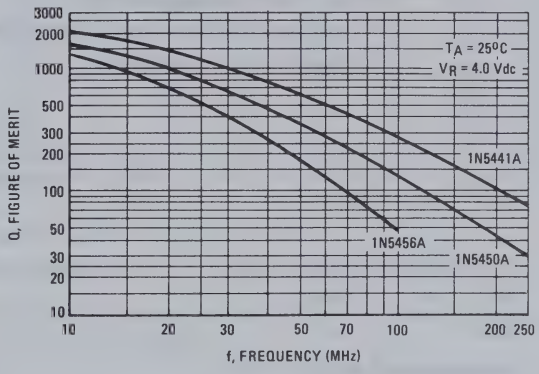


FIGURE 5 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

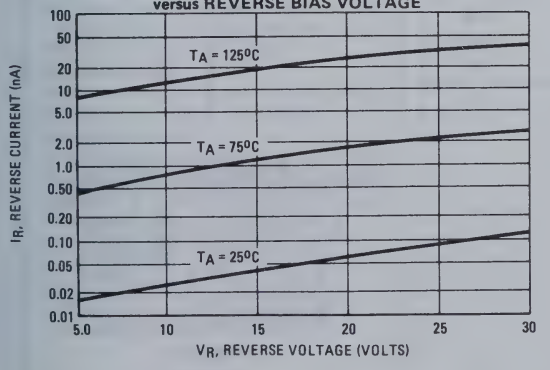
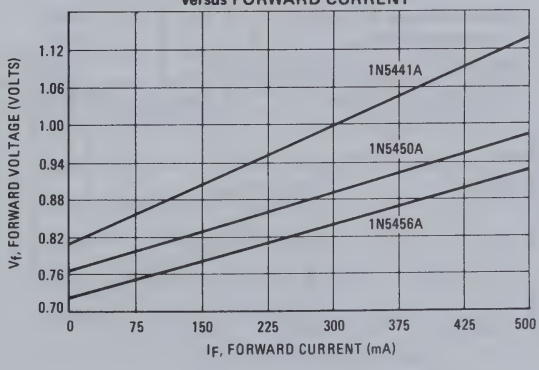


FIGURE 6 – FORWARD VOLTAGE versus FORWARD CURRENT



1N5461A,B,C (SILICON)
thru
1N5476A,B,C

VVC

SILICON EPICAP DIODES

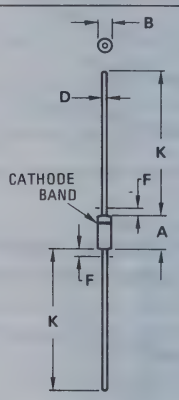
. . . a PREMIUM line of epitaxial, passivated, abrupt-junction tuning diodes for critical and sophisticated frequency control applications through the UHF range.

- High Q at High Frequencies
- Guaranteed High Capacitance Tuning Range
- Excellent Unit-to-Unit Uniformity
- Guaranteed Temperature Coefficient
- Capacitance Tolerances – 10%, 5.0%, and 2.0%
- Complete Typical Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8 – 100 pF
30 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

**MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.67	mW mW/^oC
Operating Junction Temperature Range	T_J	+175	^oC
Storage Temperature Range	T_{stg}	–65 to +200	^oC

**Indicates JEDEC Registered Data.

**ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 25 Vdc, T_A = 25°C V_R = 25 Vdc, T_A = 150°C	I_R	– –	– –	0.02 20	μAdc
Series Inductance	f = 250 MHz, lead length ≈1/16"	L_S	–	4.0	10	nH
Case Capacitance	f = 1.0 MHz, lead length ≈ 1/16"	C_C	0.1	0.17	0.25	pF
Diode Capacitance Temperature Coefficient (Note 6)	V_R = 4.0 Vdc, f = 1.0 MHz	TC_C	–	300	400	ppm/°C

Device	C_T, Diode Capacitance* V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom -10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5461A	6.1	6.8	7.5	2.7	3.1	600
1N5462A	7.4	8.2	9.0	2.8	3.1	600
1N5463A	9.0	10.0	11.0	2.8	3.1	550
1N5464A	10.8	12.0	13.2	2.8	3.1	550
1N5465A	13.5	15.0	16.5	2.8	3.1	550
1N5466A	16.2	18.0	19.8	2.9	3.1	500
1N5467A	18.0	20.0	22.0	2.9	3.1	500
1N5468A	19.8	22.0	24.2	2.9	3.2	500
1N5469A	24.3	27.0	29.7	2.9	3.2	500
1N5470A	29.7	33.0	36.3	2.9	3.2	500
1N5471A	35.1	39.0	42.9	2.9	3.2	450
1N5472A	42.3	47.0	51.7	2.9	3.2	400
1N5473A	50.4	56.0	61.6	2.9	3.3	300
1N5474A	61.2	68.0	74.8	2.9	3.3	250
1N5475A	73.8	82.0	90.2	2.9	3.3	225
1N5476A	90.0	100.0	110.0	2.9	3.3	200

*To order devices with C_T Nom ±5.0% or ±2.0% add Suffix B or C respectively.

**Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **TR, Tuning Ratio**
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specifiied frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

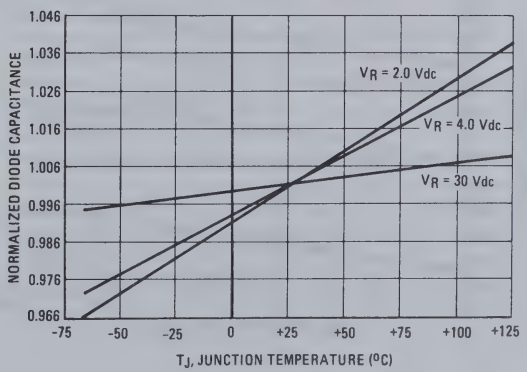
(Boonton Electronics Model 33AS8 or equivalent).

6. **TC_C, Diode Capacitance Temperature Coefficient**
   TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 – DIODE CAPACITANCE versus REVERSE VOLTAGE

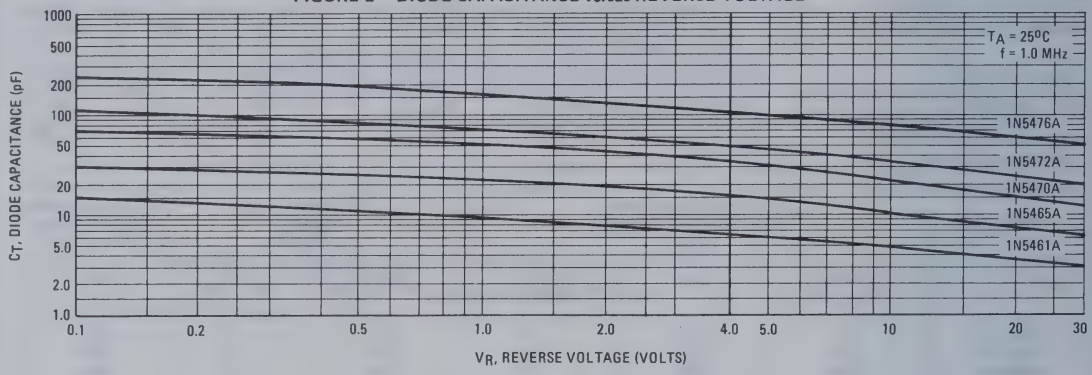


FIGURE 3 – FIGURE OF MERIT versus REVERSE VOLTAGE

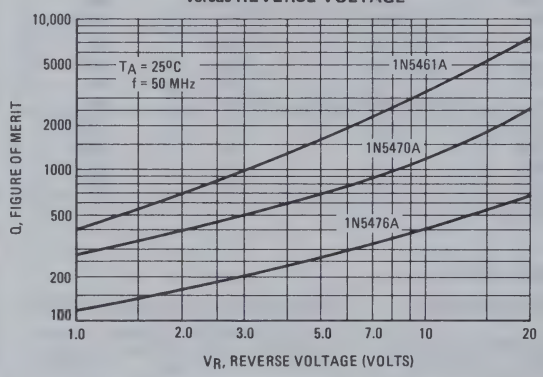


FIGURE 4 – FIGURE OF MERIT versus FREQUENCY

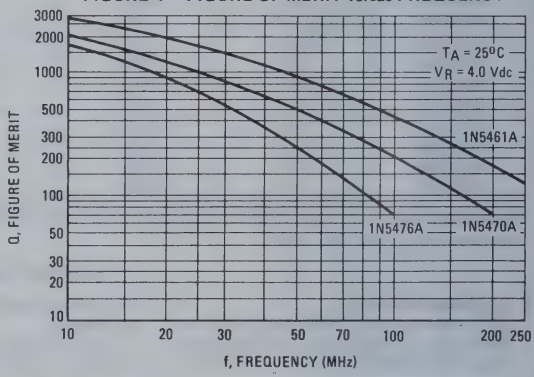


FIGURE 5 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

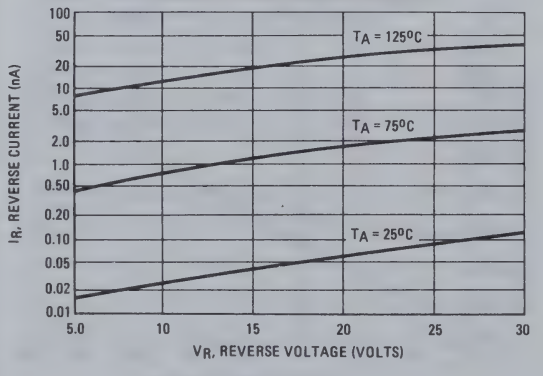
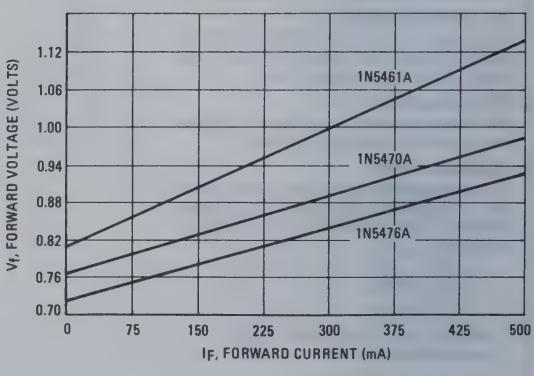


FIGURE 6 – FORWARD VOLTAGE versus FORWARD CURRENT



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:

- C_J — Voltage-Variable Junction Capacitance
- R_S — Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C — Case Capacitance
- L_S — Series Inductance
- R_J — Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

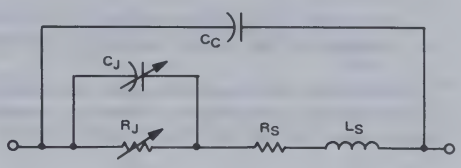


FIGURE 8



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts) •
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.17$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{max} \quad \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{10}$$

$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \tag{11}$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants

1N5518, A, B (SILICON)
thru
1N5546, A, B

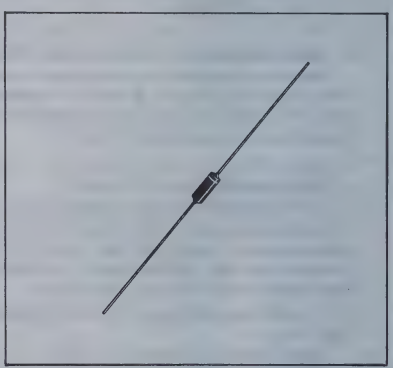
LOW VOLTAGE AVALANCHE SILICON OXIDE PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Zener Noise Specified
- Low Maximum Regulation Factor
- Low Zener Impedance
- Low Leakage Current
- Controlled Forward Characteristics
- Temperature Range: -65 to +200°C

LOW VOLTAGE AVALANCHE ZENER DIODES

400 MILLIWATTS
3.3 THRU 33 VOLTS



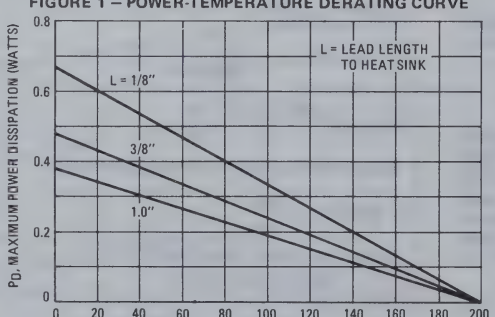
MAXIMUM RATINGS

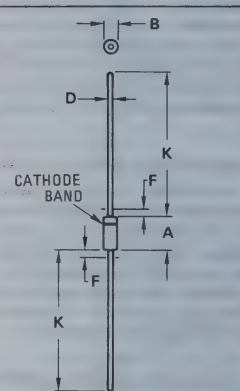
Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 50°C Derate above 50°C	P_D	400 2.66	mW mW/°C
DC Power Dissipation @ T_L = 50°C Lead Length = 1/8" Derate above 50°C (Figure 1)	P_D	500 3.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass
DIMENSIONS: See outline drawing.
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.
POLARITY: Cathode indicated by polarity band.
WEIGHT: 0.2 Gram (approx)
MOUNTING POSITION: Any

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; V_F = 1.1 Max @ I_F = 200 mA for all types)

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mAdc	Max Zener Impedance B-C-D Suffix Z_{ZT} @ I_{ZT} Ohms (Note 3)	Max Reverse Leakage Current I_R μAdc (Note 4)	Max Reverse Leakage Current V_R – Volts Non & A-Suffix	Max Reverse Leakage Current V_R – Volts B-C-D Suffix	B-C-D Suffix Maximum DC Zener Current I_{ZM} mAdc (Note 5)	B-C-D Suffix Max Noise Density at I_Z = 250 μA N_D (Figure 1) (micro-volts per square root cycle)	Regulation Factor ΔV_Z Volts (Note 6)	Low V_Z Current I_{ZL} mAdc
1N5518	3.3	20	26	5.0	0.90	1.0	115	0.5	0.90	2.0
1N5519	3.6	20	24	3.0	0.90	1.0	105	0.5	0.90	2.0
1N5520	3.9	20	22	1.0	0.90	1.0	98	0.5	0.85	2.0
1N5521	4.3	20	18	3.0	1.0	1.5	88	0.5	0.75	2.0
1N5522	4.7	10	22	2.0	1.5	2.0	81	0.5	0.60	1.0
1N5523	5.1	5.0	26	2.0	2.0	2.5	75	0.5	0.65	0.25
1N5524	5.6	3.0	30	2.0	3.0	3.5	68	1.0	0.30	0.25
1N5525	6.2	1.0	30	1.0	4.5	5.0	61	1.0	0.20	0.01
1N5526	6.8	1.0	30	1.0	5.5	6.2	56	1.0	0.10	0.01
1N5527	7.5	1.0	35	0.5	6.0	6.8	51	2.0	0.05	0.01
1N5528	8.2	1.0	40	0.5	6.5	7.5	46	4.0	0.05	0.01
1N5529	9.1	1.0	45	0.1	7.0	8.2	42	4.0	0.05	0.01
1N5530	10.0	1.0	60	0.05	8.0	9.1	38	4.0	0.10	0.01
1N5531	11.0	1.0	80	0.05	9.0	9.9	35	5.0	0.20	0.01
1N5532	12.0	1.0	90	0.05	9.5	10.8	32	10	0.20	0.01
1N5533	13.0	1.0	90	0.01	10.5	11.7	29	15	0.20	0.01
1N5534	14.0	1.0	100	0.01	11.5	12.6	27	20	0.20	0.01
1N5535	15.0	1.0	100	0.01	12.5	13.5	25	20	0.20	0.01
1N5536	16.0	1.0	100	0.01	13.0	14.4	24	20	0.20	0.01
1N5537	17.0	1.0	100	0.01	14.0	15.3	22	20	0.20	0.01
1N5538	18.0	1.0	100	0.01	15.0	16.2	21	20	0.20	0.01
1N5539	19.0	1.0	100	0.01	16.0	17.1	20	20	0.20	0.01
1N5540	20.0	1.0	100	0.01	17.0	18.0	19	20	0.20	0.01
1N5541	22.0	1.0	100	0.01	18.0	19.8	17	20	0.25	0.01
1N5542	24.0	1.0	100	0.01	20.0	21.6	16	20	0.30	0.01
1N5543	25.0	1.0	100	0.01	21.0	22.4	15	20	0.35	0.01
1N5544	28.0	1.0	100	0.01	23.0	25.2	14	20	0.40	0.01
1N5545	30.0	1.0	100	0.01	24.0	27.0	13	20	0.45	0.01
1N5546	33.0	1.0	100	0.01	28.0	29.7	12	20	0.50	0.01

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

The JEDEC type numbers shown are ±20% with guaranteed limits for only V_Z, I_R, and V_F. Units with "A" suffix are ±10% with guaranteed limits for V_Z, I_R, and V_F. Units with guaranteed limits for all six parameters are indicated by a "B" suffix for ±5.0% units, "C" suffix for ±2.0% and "D" suffix for ±1.0%.

NOTE 2 – ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium with ambient temperature of 25°C.

NOTE 3 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 Hz ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed on I_{ZT}.

NOTE 4 – REVERSE LEAKAGE CURRENT (I_R)

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

NOTE 5 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5.0% type unit, therefore, it applies only to the "B" suffix device. The actual I_{ZM} for any device may not exceed the value of 400 milliwatts divided by the actual V_Z of the device.

NOTE 6 – MAXIMUM REGULATION FACTOR (ΔV_Z)

ΔV_Z is the maximum difference between V_Z at I_{ZT} and V_Z at I_{ZL} measured with the device junction in thermal equilibrium.

ZENER NOISE DENSITY

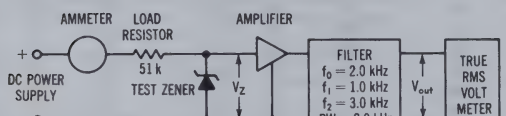
A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

Motorola is rating this series with a maximum noise density at 250 microamperes, a bandwidth of 2.0 kHz and a center frequency of 2.0 kHz.

Noise density decreases as zener current increases. The junction temperature will also change the zener noise levels, thus the noise rating must indicate frequency, bandwidth, current level and temperature.

The block diagram shown in Figure 2 represents the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter frequency and bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 2 – NOISE DENSITY MEASUREMENT METHOD



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH)} = \frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 3 – TYPICAL CAPACITANCE

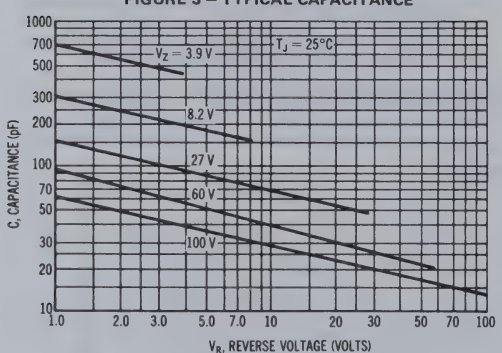
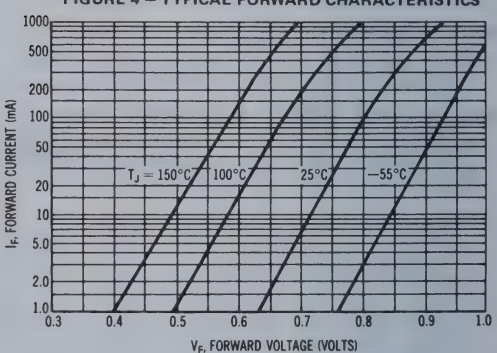


FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS



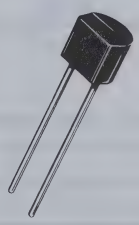
1N5758,A thru 1N5762,A (SILICON)

SILICON 3-LAYER BILATERAL TRIGGERS

... Annular , two terminal devices that exhibit bi-directional negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits for lamp drivers and universal motor speed controls.

- Switching Voltage Range – 20 to 36 Volts Nominal
- Symmetrical Characteristics
- Passivated Surface for Reliability and Uniformity

SILICON BILATERAL TRIGGERS



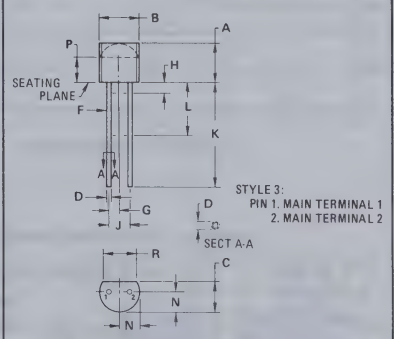
***MAXIMUM RATINGS** (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Switching Voltage (Both Directions)	1N5758	V_S	16	24	Volts
	1N5759		20	28	
	1N5760		24	32	
	1N5761		28	36	
	1N5762		32	40	
	1N5758A		18	22	
	1N5759A		22	26	
	1N5760A		26	30	
	1N5761A		30	34	
	1N5762A		34	38	
Switching Current (Both Directions)	1N5758/5762	I_S	–	100	μA
(T_A = -40 to +75°C)	1N5758A/5762A		–	25	
Switching Voltage Change (Both Directions)	1N5758,A,1N5759,A	ΔV	5.0	–	Volts
(ΔI = I_S to I = 10 mA)	1N5760,A,61,A,62,A		7.0	–	
Leakage Current (Both Directions), (Applied Voltage = 14 Volts)		I_B	–	10	μA
Switching Voltage Symmetry	1N5758/5762	$(V_S+)-(V_S-)$	–	± 4.0	Volts
	1N5758A/5762A		–	± 2.0	
Peak Pulse Amplitude (Figure 1) (Both Polarities)	1N5758,A,1N5759,A		3.0	–	Volts
	1N5760,A,61,A,62,A		5.0	–	

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

CASE 182-02

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – PEAK PULSE AMPLITUDE TEST CIRCUIT

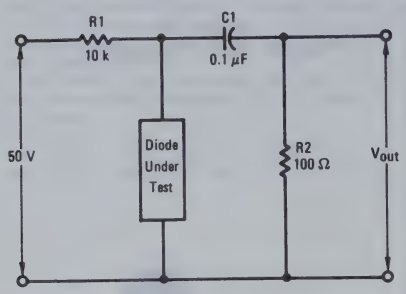


FIGURE 2 – VOLT-AMPERE CHARACTERISTICS

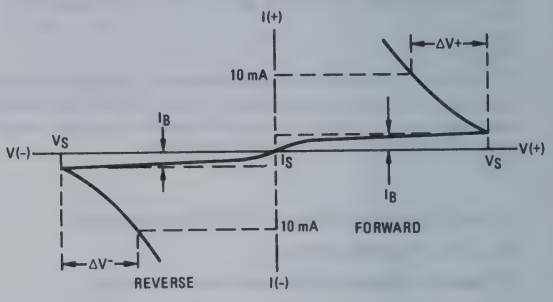


FIGURE 3 – BREAKOVER VOLTAGE BEHAVIOR

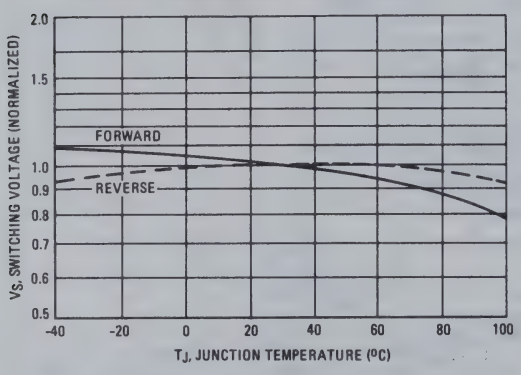


FIGURE 4 – NORMALIZED OUTPUT VOLTAGE BEHAVIOR

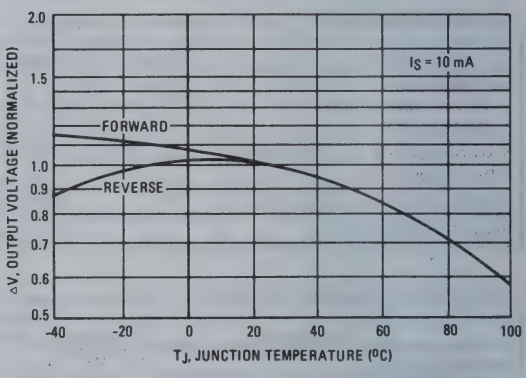


FIGURE 5 – SWITCHING TIMES

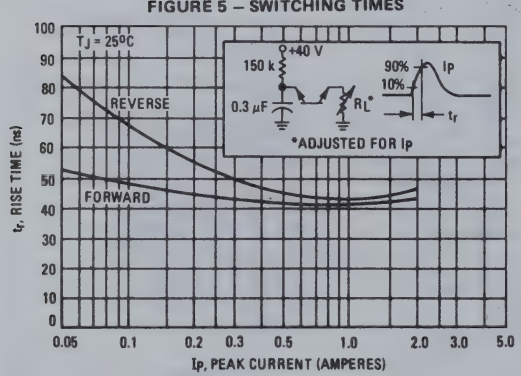
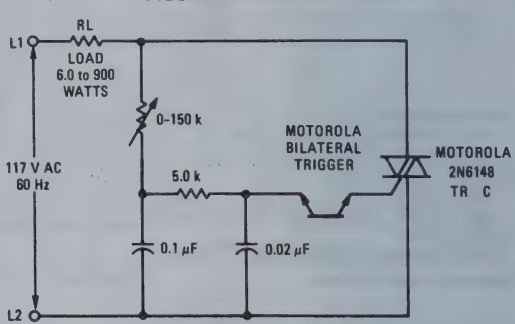


FIGURE 6 – CONTROL CIRCUIT



1N5779 thru 1N5793 For Specifications, See 1N5158 Data.

1N5823, 1N5824, 1N5825 (SILICON)

Designers Data Sheet

HOT CARRIER POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N5823	1N5824	1N5825	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2 V_R$ (dc), $T_C = 75^oC$ $V_{R(equiv)} \leq 0.2 V_R$ (dc), $T_L = 80^oC$ ($R_{\theta JA} = 25^oC/W$, P.C. Board Mounting, See Note 3)	I_O	← 15 → ← 5.0 →			Amp
Ambient Temperature Rated V_R (dc), $P_{F(AV)} = 0$ $R_{\theta JA} = 25^oC/W$	T_A	65	60	55	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

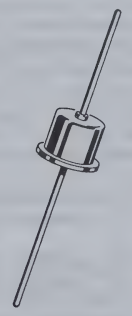
Characteristic	Symbol	1N5823	1N5824	1N5825	Unit
Maximum Instantanous Forward Voltage (1) (i_F = 3.0 Amp) (i_F = 5.0 Amp) (i_F = 15.7 Amp)	v_F	 0.330 0.360 0.470	 0.340 0.370 0.490	 0.350 0.380 0.520	Volts
Maximum Instantanous Reverse Current @ rated dc Voltage $T_C = 25^oC$ $T_C = 100^oC$	I_R	 10 75	 10 75	 10 75	mA

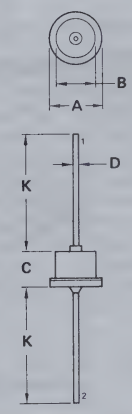
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

*Indicates JEDEC Registered Data.

SCHOTTKY BARRIER RECTIFIERS

5 AMPERE
20, 30, 40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal leads are readily solderable.

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 125°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{IN(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5825 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 10°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (1.41)(10)(0.65) = 9.2$ V

Step 2: Find T_R from Figure 3. Read T_R = 118°C @ V_R = 9.2 V & $R_{\theta JA}$ = 10°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 4. †Read $P_{F(AV)}$ = 5.5 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 118-(10)(5.5) = 63°C.

†Values given are for the 1N5825. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit / Load	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$ (2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5823

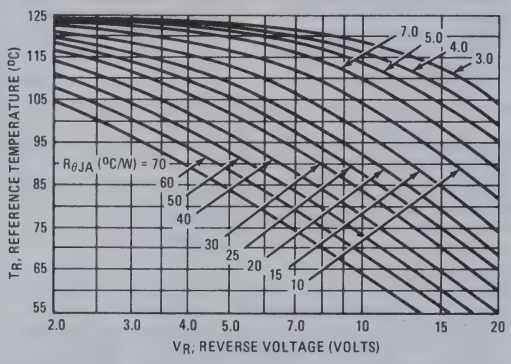


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5824

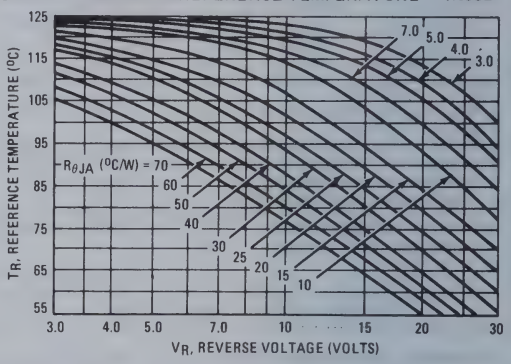


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5825

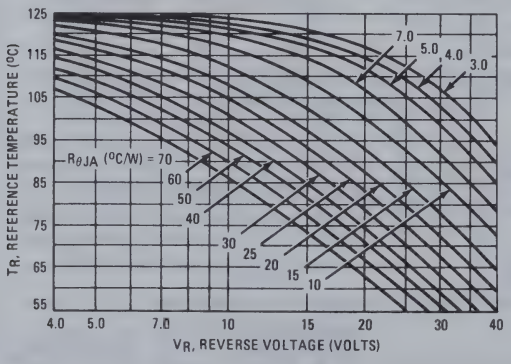
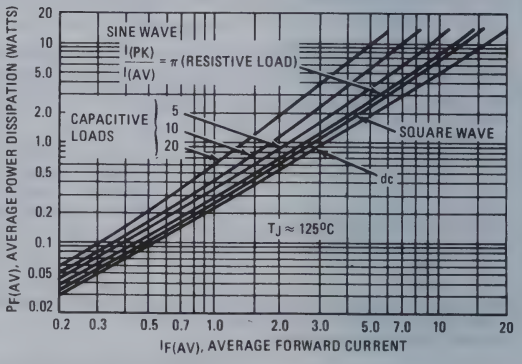
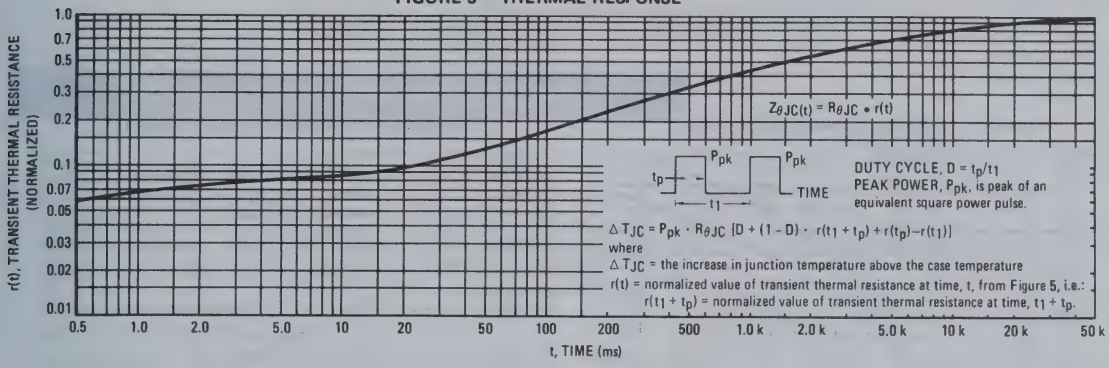


FIGURE 4 – FORWARD POWER DISSIPATION

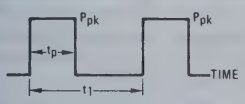


THERMAL CHARACTERISTICS

FIGURE 5 – THERMAL RESPONSE



NOTE 2 – FINDING JUNCTION TEMPERATURE



DUTY CYCLE, D = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

r(t) = normalized value of transient thermal resistance at time, t, from Figure 5, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

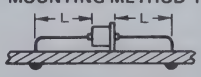
NOTE 3 – MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering.

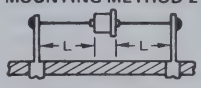
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)		
	1/4	1	$R_{\theta JA}$
1	55	60	°C/W
2	65	70	°C/W
3	25		°C/W

MOUNTING METHOD 1



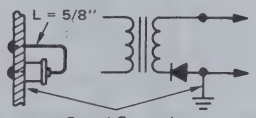
MOUNTING METHOD 2



Vector pin mounting

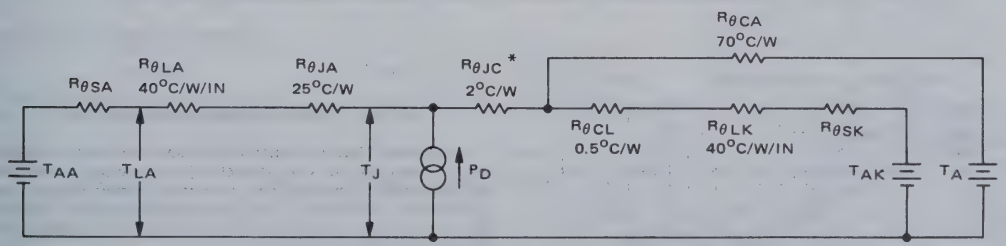
MOUNTING METHOD 3

P. C. Board with 2 1/2" x 2 1/2" copper surface



Board Ground Plane

FIGURE 6 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits calculation of average junction temperature for any mounting situation. Lowest values of thermal resistance will occur when the cathode lead is brought as close as possible to a heat dissipator; as heat conduction through the anode lead is small. Terms in the model are defined as follows:

*Case temperature reference is at cathode end.

TEMPERATURES

T_A = Ambient
T_{AA} = Anode Heat Sink Ambient
T_{AK} = Cathode Heat Sink Ambient
T_{LA} = Anode Lead
T_{LK} = Cathode Lead
T_J = Junction

THERMAL RESISTANCES

$R_{\theta CA}$ = Case to Ambient
$R_{\theta SA}$ = Anode Lead Heat Sink to Ambient
$R_{\theta SK}$ = Cathode Lead Heat Sink to Ambient
$R_{\theta LA}$ = Anode Lead
$R_{\theta LK}$ = Cathode Lead
$R_{\theta CL}$ = Case to Cathode Lead
$R_{\theta JC}$ = Junction to Case
$R_{\theta JA}$ = Junction to Anode Lead (S bend)

FIGURE 7 – TYPICAL FORWARD VOLTAGE

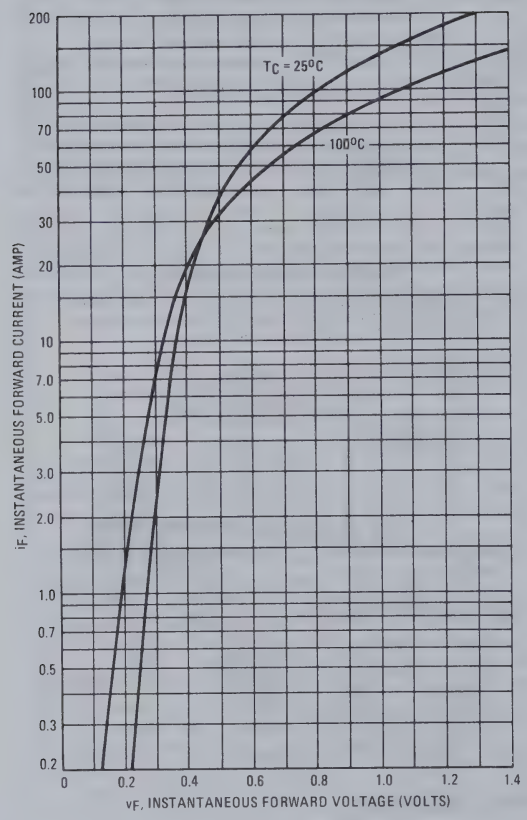


FIGURE 8 – MAXIMUM SURGE CAPABILITY

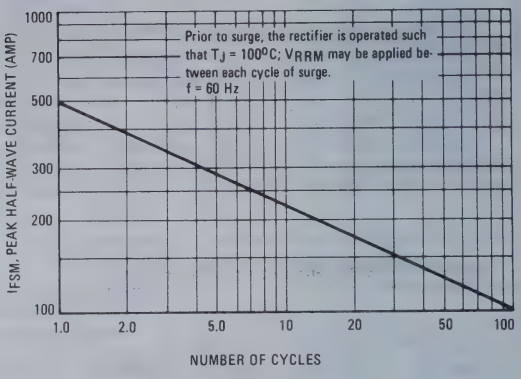


FIGURE 9 – TYPICAL REVERSE CURRENT

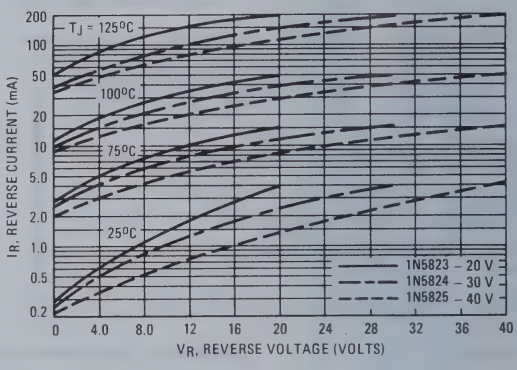
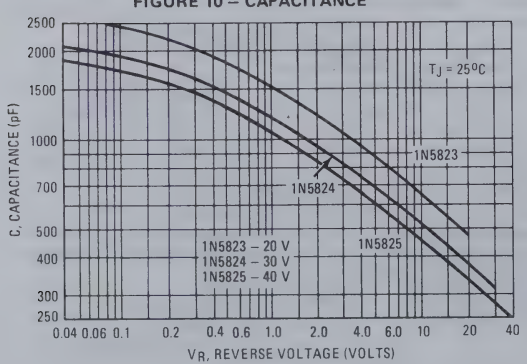


FIGURE 10 – CAPACITANCE



NOTE 4 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

1N5826, 1N5827, 1N5828 (SILICON)

Designers Data Sheet

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

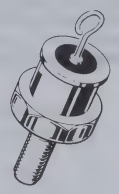
- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

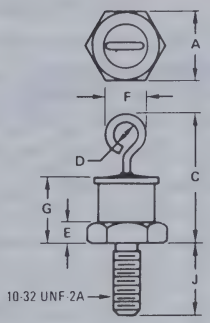
Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

SCHOTTKY BARRIER RECTIFIERS

15 AMPERE
20,30,40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	20.32	–	0.800
D	1.52	–	0.060	–
E	1.91	4.45	0.075	0.175
F	–	6.35	–	0.250
G	–	10.29	–	0.405
J	10.72	11.51	0.422	0.453

CASE 245

*MAXIMUM RATINGS

Rating	Symbol	1N5826	1N5827	1N5828	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 85^oC$	I_O	← 15 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 5.0^oC/W$	T_A	95	90	85	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	1N5826	1N5827	1N5828	Unit
Maximum Instantaneous Forward Voltage (1)	v_F				Volts
(i_F = 8.0 Amp)		0.380	0.400	0.420	
(i_F = 15 Amp)		0.440	0.470	0.500	
(i_F = 47.1 Amp)		0.670	0.770	0.870	
Maximum Instantaneous Reverse Current @ rated dc Voltage (1)	I_R				mA
$T_C = 100^oC$		10 75	10 75	10 75	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 15 in. lb. max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5828 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 121°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. †Read $P_{F(AV)}$ = 10 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 121-(5)(10) = 71°C

†Values given are for the 1N5828. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5826

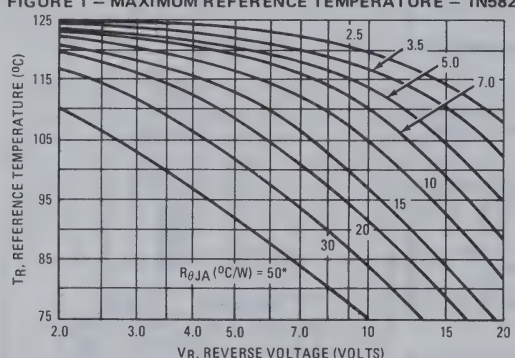


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5827

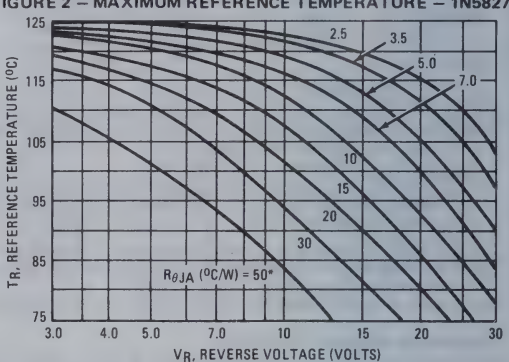


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5828

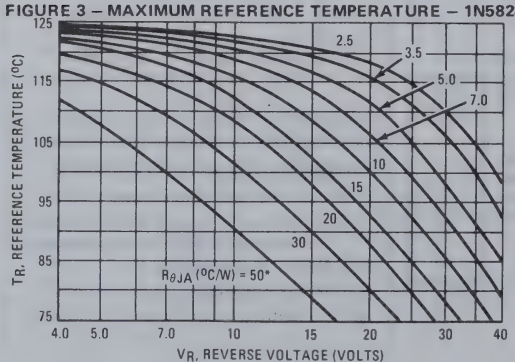


FIGURE 4 – FORWARD POWER DISSIPATION

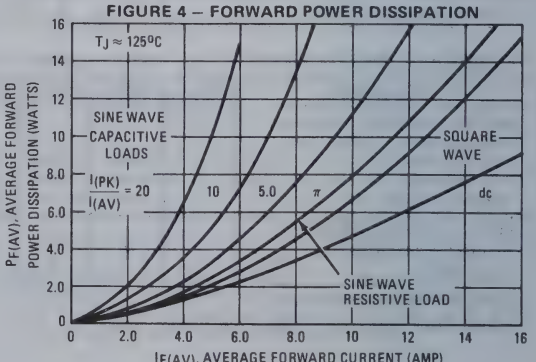


FIGURE 5 – TYPICAL FORWARD VOLTAGE

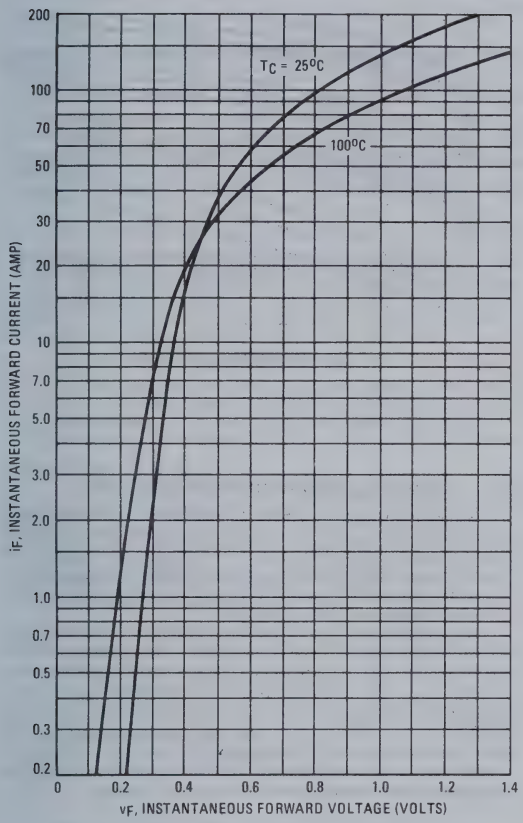


FIGURE 6 – MAXIMUM SURGE CAPABILITY

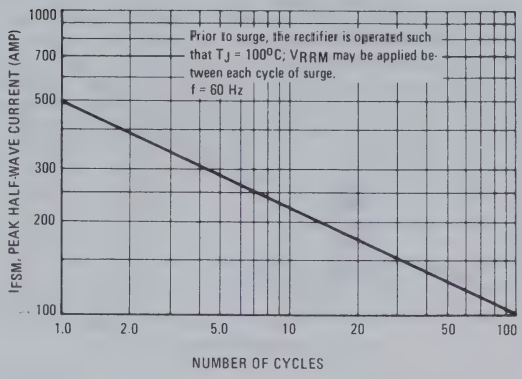


FIGURE 7 – CURRENT DERATING

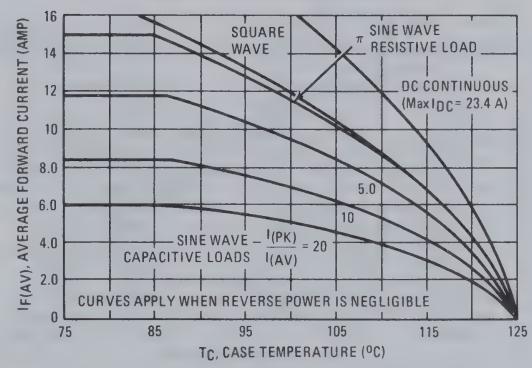


FIGURE 8 – THERMAL RESPONSE

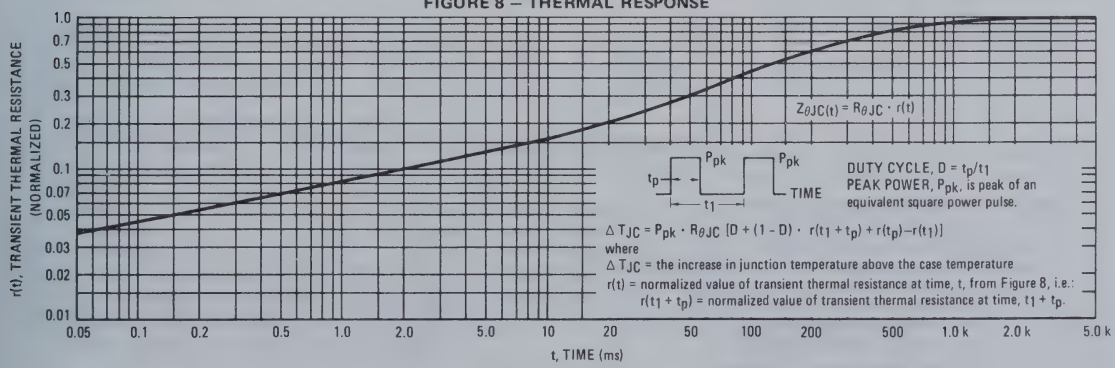


FIGURE 9 – NORMALIZED REVERSE CURRENT

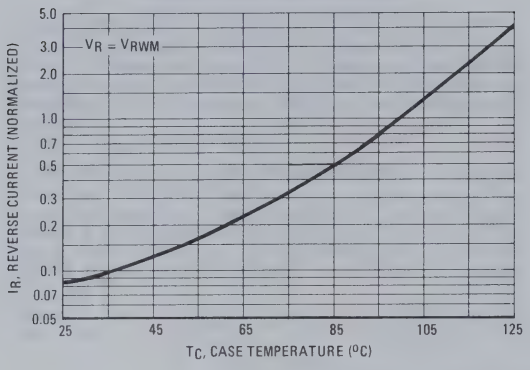


FIGURE 10 – TYPICAL REVERSE CURRENT

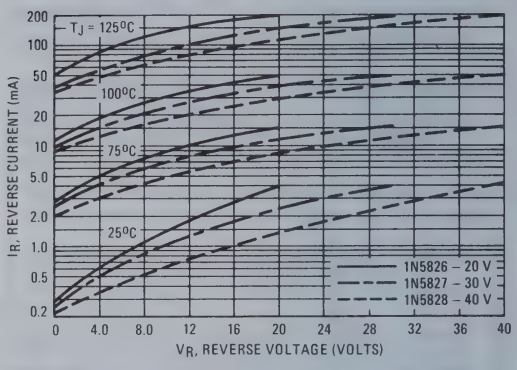
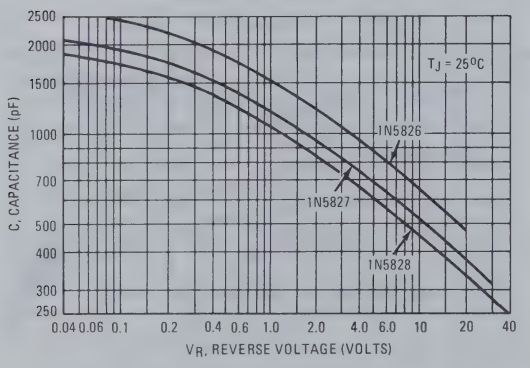


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

1N5829, 1N5830, 1N5831 (SILICON)

Designers Data Sheet

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

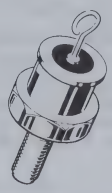
- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

SCHOTTKY BARRIER RECTIFIERS

25 AMPERE
20, 30, 40 VOLTS



*MAXIMUM RATINGS

Rating	Symbol	1N5829	1N5830	1N5831	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv.)} \leq 0.2\ V_{R(dc)}$, $T_C = 85^oC$	I_O	← 25 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 3.5^oC/W$	T_A	90	85	80	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	800 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

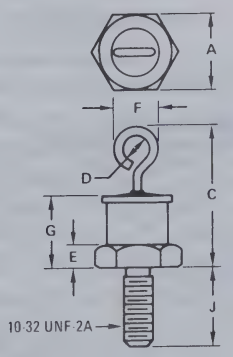
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	1N5829	1N5830	1N5831	Unit
Maximum Instantaneous Forward Voltage(1) (i_F = 10 Amp) (i_F = 25 Amp) (i_F = 78.5 Amp)	v_F	 0.360 0.440 0.720	 0.370 0.460 0.770	 0.380 0.480 0.820	Volts
Maximum Instantaneous Reverse Current @Rated dc Voltage(1) (T_C= 100°C)	I_R	20 150	20 150	20 150	mA

*Indicates JEDEC Registered Data

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	20.32	–	0.800
D	1.52	–	0.060	–
E	1.91	4.45	0.075	0.175
F	–	6.35	–	0.250
G	–	10.29	–	0.405
J	10.72	11.51	0.422	0.453

CASE 245

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITIONS: Any

STUD TORQUE: 15 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R \leq T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 125°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5831 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 16 A ($I_{F(AV)}$ = 8 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA} = 5°C/W$.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (1.41)(10)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read $T_R = 113°C$ @ $V_R = 9.18$ & $R_{\theta JA} = 5°C/W$

Step 3: Find $P_{F(AV)}$ from Figure 4. †Read $P_{F(AV)} = 12.8$ W @ $\frac{I_{(PK)}}{I_{(AV)}} = 20$ & $I_{F(AV)} = 8$ A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)} = 113-(5)(12.8) = 49°C$

†Values given are for the 1N5831. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5829

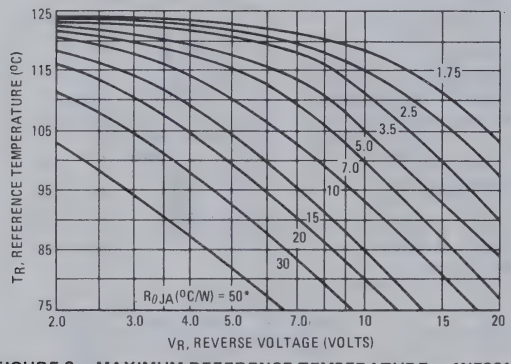


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5830

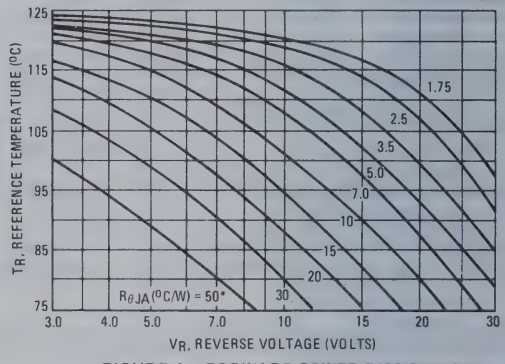
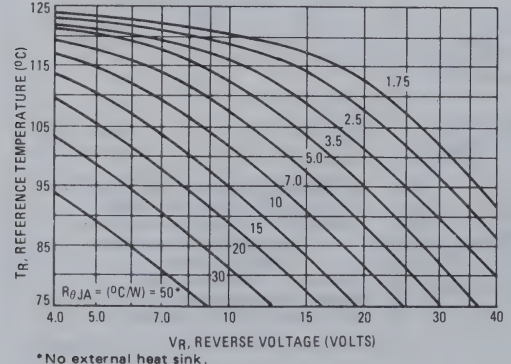


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5831



*No external heat sink.

FIGURE 4 – FORWARD POWER DISSIPATION

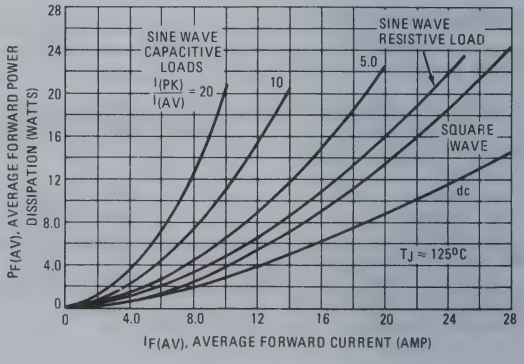


FIGURE 5 – TYPICAL FORWARD VOLTAGE

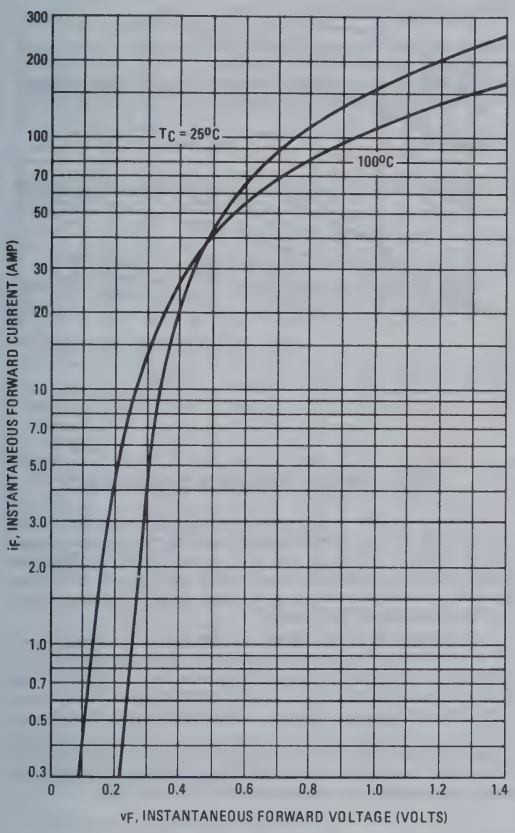


FIGURE 6 – MAXIMUM SURGE CAPABILITY

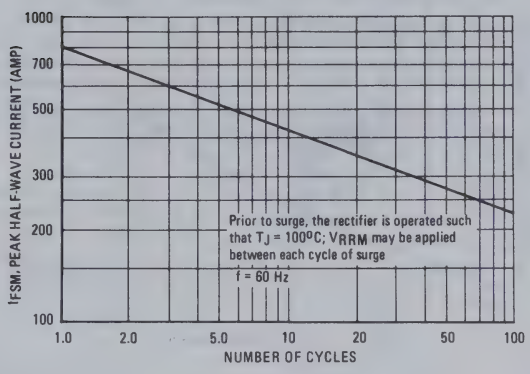


FIGURE 7 – CURRENT DERATING

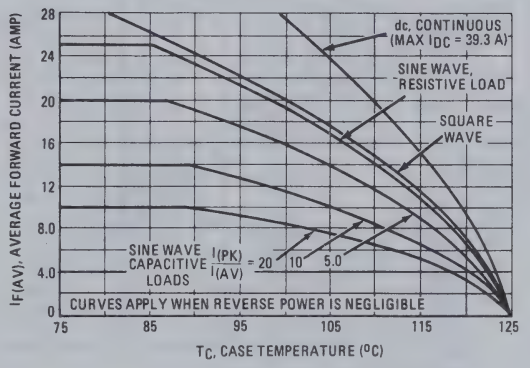


FIGURE 8 – THERMAL RESPONSE

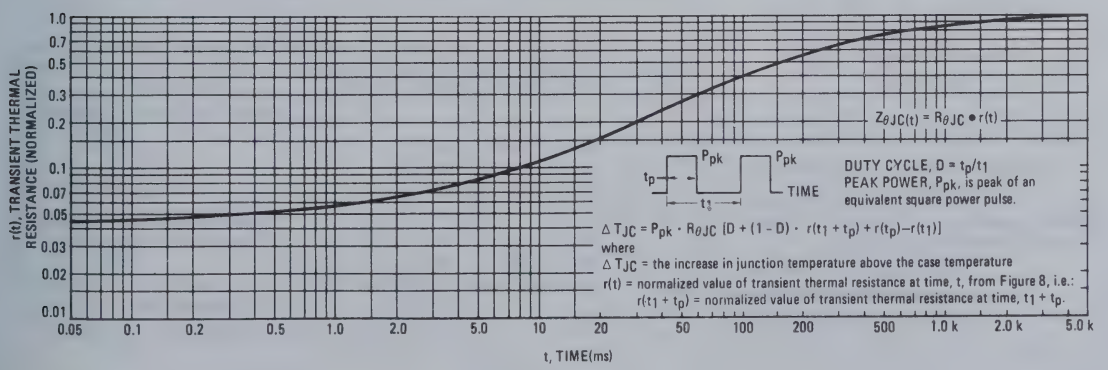


FIGURE 9 – NORMALIZED REVERSE CURRENT

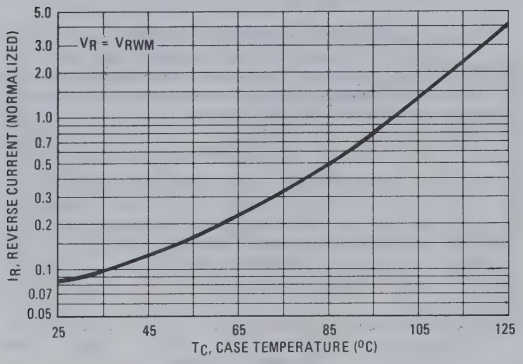


FIGURE 10 – TYPICAL REVERSE CURRENT

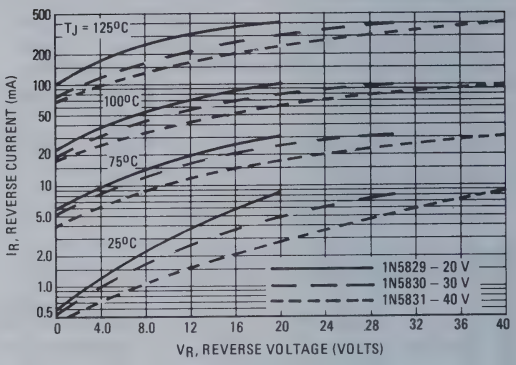
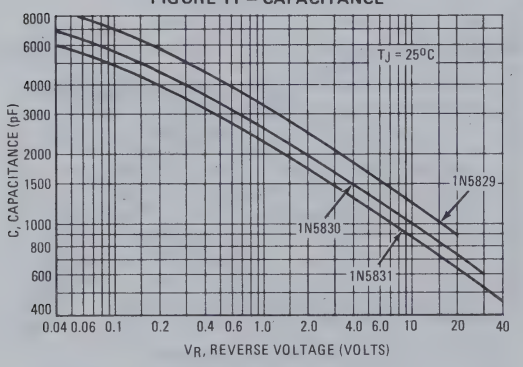


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

1N5832, 1N5833, 1N5834 (SILICON)

Designers Data Sheet

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

Designer's Data for "Worst Case" Conditions

The Designers▲ Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N5832	1N5833	1N5834	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}, T_C = 75^oC$	I_O	← 40 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 2.0^oC/W$	T_A	100	95	90	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	1N5832	1N5833	1N5834	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 10 Amp) (i_F = 40 Amp) (i_F = 125 Amp)	v_F	 0.360 0.520 0.980	 0.370 0.550 1.080	 0.380 0.590 1.180	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	I_R	 20 150	 20 150	 20 150	mA

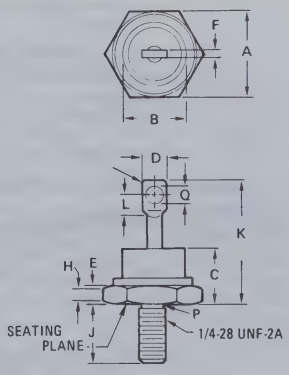
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE 20,30,40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.667	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
H	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.96	–	0.152	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175

NOTES:
1. Dimension "P" is diameter.
2. All JEDEC dimensions and notes apply.

CASE 257-01
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 125°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5834 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 3°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (10)(1.41)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read T_R = 118°C @ V_R = 9.18 V & $R_{\theta JA}$ = 3°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4.†Read $P_{F(AV)}$ = 20 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 15 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)} = 118-(3)(20) = 58°C$

†Values given are for the 1N5834. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5832

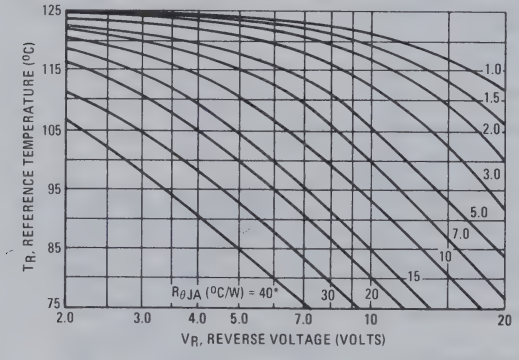


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5833

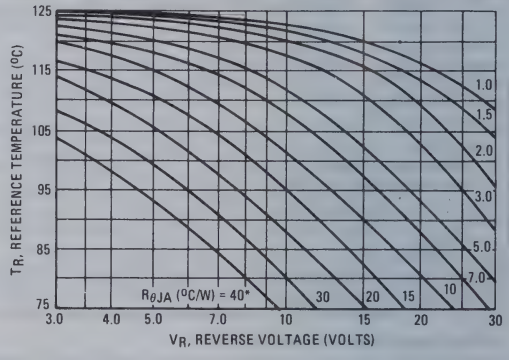
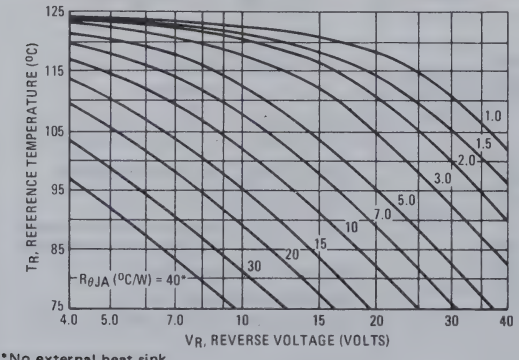


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5834



*No external heat sink.

FIGURE 4 – FORWARD POWER DISSIPATION

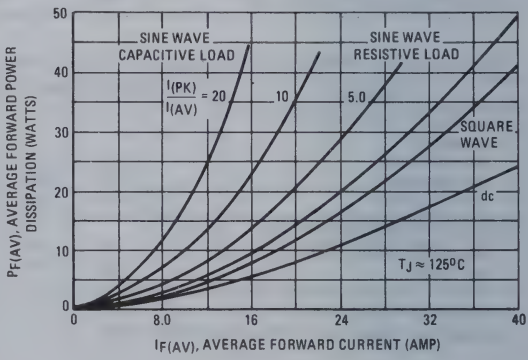


FIGURE 5 – TYPICAL FORWARD VOLTAGE

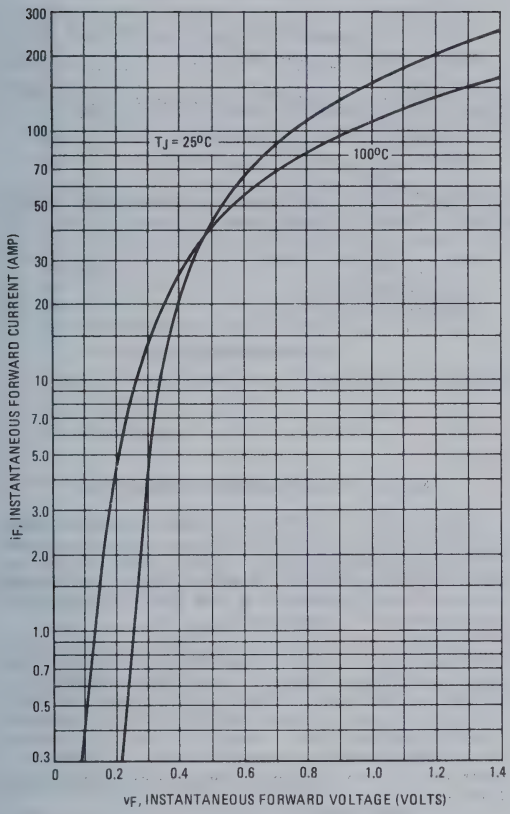


FIGURE 6 – MAXIMUM SURGE CAPABILITY

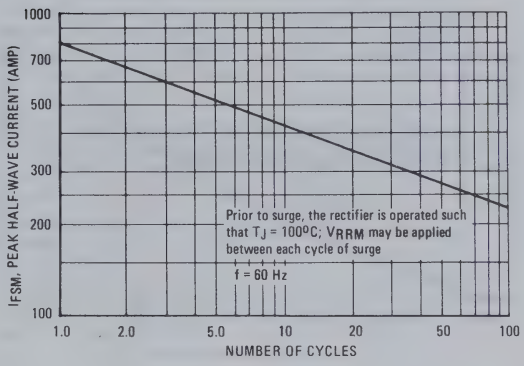


FIGURE 7 – CURRENT DERATING

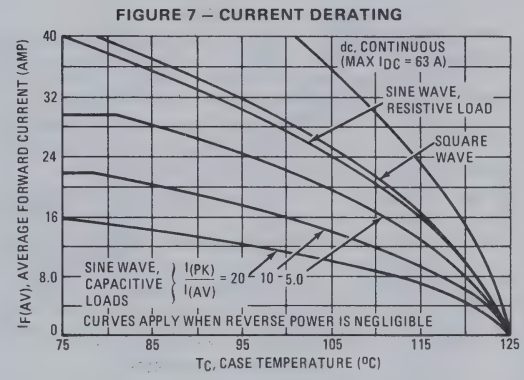


FIGURE 8 – THERMAL RESPONSE

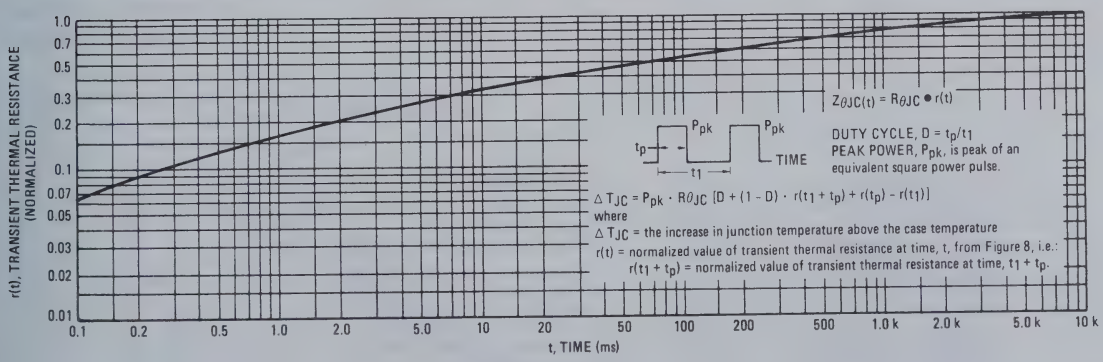


FIGURE 9 – NORMALIZED REVERSE CURRENT

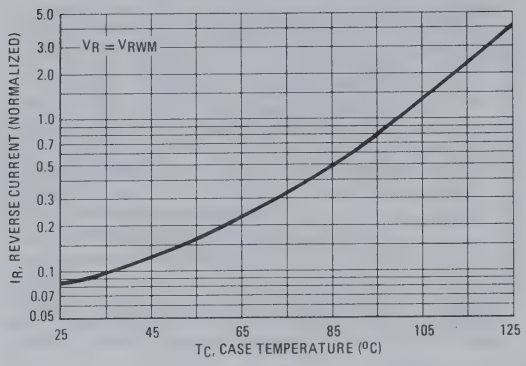


FIGURE 10 – TYPICAL REVERSE CURRENT

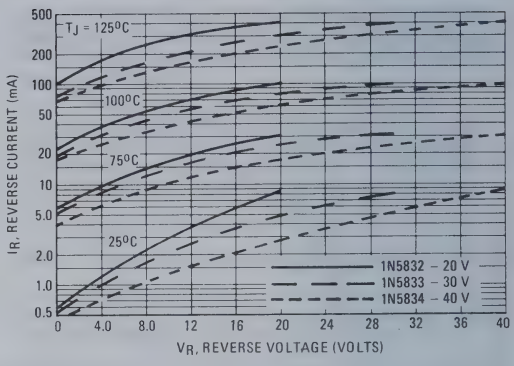
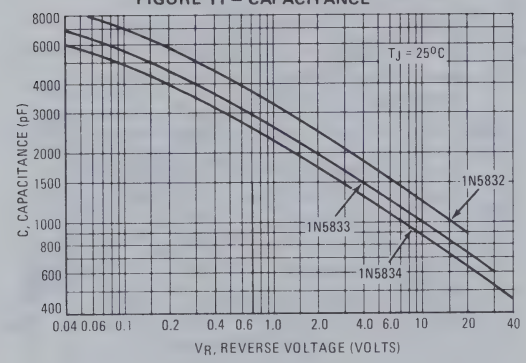


FIGURE 11 – CAPACITANCE



NOTE 2 HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

1N5837A thru 1N5897A

500 mW UNIBLOC SILICON OXIDE-PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. Supplied in the popular TO-92 plastic package for the high volume requirements of the consumer industry.

- In-Line Leads for Easy Insertion
- Lower Cost in High Volume
- Electrically Similar to the Popular Surmetic 20 Series "1N5221 – 1N5281"
- Wide Voltage Selection – 2.4-200 V

UNIBLOC ZENER REGULATOR DIODES

500 MILLIWATTS
2.4 thru 200 VOLTS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 55^oC$ Lead Length = 1/4"	P_D	500	mW
Derate above 55^oC (Figure 1)		5.26	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded, thermosetting plastic

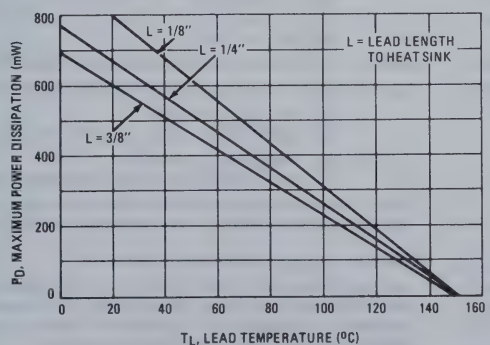
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable and weldable

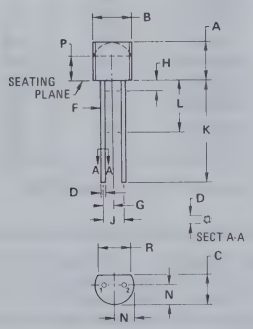
POLARITY: Cathode indicated by color dot. (When operated in zener mode, cathode will be positive with respect to anode.)

MOUNTING POSITION: Any

WEIGHT: 0.18 gram (approx)

FIGURE 1 – POWER-DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

CASE 182-02

ELECTRICAL CHARACTERISTICS Guaranteed when measured at 90 seconds while maintaining the lead temperature $T_L = 30 \pm 1^oC$, 3/8" from the diode body. (V_F = 1.5 Volts Max at I_F = 200 mAdc for all types.)

Motorola Type Number (Note 1)	Nominal Zener Voltage* V_Z @ I_{ZT} Volts (Note 2)	Test Current* I_{ZT} mA	Max. Zener Impedance * Z_{ZT} @ I_{ZT} Ohms	Max. Zener Impedance * Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	Max. Reverse * Leakage Current I_R μA at V_R volts		Maximum DC Zener Current I_{ZM}* mAdc	Maximum Surge Current $I_{Z(surge)}$* mAdc (Note 4)	Typical Zener Voltage Temp. Coeff. θ_{VZ} (%/°C) (Note 3)
1N5837A	2.4	20	50	2100	100	1.0	210	1041.7	-1.03
1N5838A	2.5	20	50	2100	100	1.0	200	1000.0	-1.03
1N5839A	2.7	20	50	2200	75	1.0	185	925.9	-1.01
1N5840A	2.8	20	50	2200	75	1.0	179	892.9	-1.00
1N5841A	3.0	20	50	2300	50	1.0	167	833.3	-0.09
1N5842A	3.3	20	50	2500	25	1.0	151	757.6	-0.068
1N5843A	3.6	20	48	2700	15	1.0	139	694.4	-0.051
1N5844A	3.9	20	40	2800	10	1.0	129	641.0	-0.034
1N5845A	4.3	20	25	2900	5.0	1.0	116	581.4	-0.010
1N5846A	4.7	20	19	2600	5.0	2.0	106	531.9	+0.012
1N5847A	5.1	20	17	2400	5.0	2.0	98	490.2	+0.025
1N5848A	5.6	20	15	2100	5.0	3.0	89	446.4	+0.035
1N5849A	6.0	20	13	1900	5.0	3.5	83	416.7	+0.041
1N5850A	6.2	20	14	1500	5.0	4.0	80	403.2	+0.043
1N5851A	6.8	20	17	780	3.0	5.0	74	367.6	+0.050
1N5852A	7.5	20	23	700	3.0	6.0	67	333.3	+0.055
1N5853A	8.2	20	34	700	3.0	6.5	61	304.9	+0.059
1N5854A	8.7	20	44	700	3.0	6.5	57	287.4	+0.061
1N5855A	9.1	20	50	700	3.0	7.0	55	274.7	+0.062
1N5856A	10	20	62	700	3.0	8.0	50	250.0	+0.066
1N5857A	11	20	68	700	2.0	8.4	45	227.3	+0.068
1N5858A	12	20	70	700	1.0	9.1	41.5	208.3	+0.070
1N5859A	13	9.5	70	700	0.5	9.9	38.5	538.5	+0.072
1N5860A	14	9.0	70	700	0.1	10	35.5	500.0	+0.074
1N5861A	15	8.5	34	700	0.1	11	33	466.7	+0.076
1N5862A	16	7.8	38	700	0.1	12	31	437.5	+0.077
1N5863A	17	7.4	42	700	0.1	13	29	411.8	+0.078
1N5864A	18	7.0	48	700	0.1	14	28	388.9	+0.079
1N5865A	19	6.6	52	700	0.1	14	26	368.4	+0.080
1N5866A	20	6.2	57	700	0.1	15	25	350.0	+0.080
1N5867A	22	5.6	68	700	0.1	17	22.6	318.2	+0.082
1N5868A	24	5.2	78	700	0.1	18	21.7	291.7	+0.083
1N5869A	25	5.0	85	700	0.1	19	20	280.0	+0.083
1N5870A	27	4.6	98	700	0.1	21	18.5	259.3	+0.084
1N5871A	28	4.5	105	700	0.1	21	17.9	250.0	+0.084
1N5872A	30	4.2	117	700	0.1	23	16.7	233.3	+0.085
1N5873A	33	3.8	140	700	0.1	25	15.1	212.1	+0.086
1N5874A	36	3.4	160	700	0.1	27	13.9	194.4	+0.087
1N5875A	39	3.2	190	800	0.1	30	12.9	179.5	+0.087
1N5876A	43	3.0	225	900	0.1	33	11.6	162.8	+0.088
1N5877A	47	2.7	260	1000	0.1	36	10.6	148.9	+0.088
1N5878A	51	2.5	300	1100	0.1	39	9.8	137.3	+0.089
1N5879A	56	2.2	360	1300	0.1	43	8.9	125.0	+0.089
1N5880A	60	2.1	410	1500	0.1	46	8.3	116.7	+0.090
1N5881A	62	2.0	430	1600	0.1	47	8.0	112.9	+0.090
1N5882A	68	1.8	520	1900	0.1	52	7.4	102.9	+0.090
1N5883A	75	1.7	600	2300	0.1	56	6.7	93.3	+0.090
1N5884A	82	1.5	700	2700	0.1	62	6.1	85.4	+0.090
1N5885A	87	1.4	780	3100	0.1	68	5.7	80.5	+0.091
1N5886A	91	1.4	840	3400	0.1	69	5.5	76.9	+0.091
1N5887A	100	1.3	1000	4000	0.1	76	5.0	50.0	+0.091
1N5888A	110	1.1	1200	5000	0.1	84	4.5	45.5	+0.091
1N5889A	120	1.0	1400	5100	0.1	91	4.1	41.7	+0.092
1N5890A	130	0.95	1600	5200	0.1	99	3.8	38.5	+0.092
1N5891A	140	0.90	1800	5300	0.1	106	3.5	35.7	+0.092
1N5892A	150	0.85	2100	5400	0.1	114	3.3	33.3	+0.092
1N5893A	160	0.80	2300	5500	0.1	122	3.1	31.2	+0.092
1N5894A	170	0.74	2600	5600	0.1	129	2.9	29.4	+0.092
1N5895A	180	0.68	2900	6000	0.1	137	2.8	27.8	+0.092
1N5896A	190	0.66	3200	6500	0.1	144	2.6	26.3	+0.093
1N5897A	200	0.65	3500	7000	0.1	152	2.5	25.0	+0.093

*Indicates JEDEC Registered Data.

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation – The type numbers listed indicate a tolerance of ±10%. Device tolerances of ±5% are indicated by a "B" suffix; ±2% by a "C" suffix, ±1% by a "D" suffix. ±20% tolerance should be designated as below with no suffix.

Non-Standard voltage designation – To designate units with zener voltages other than those assigned the Motorola type number should be used.

EXAMPLE:

M	Z	92	–	65	A
Motorola	Zener Diode	Series		Nominal Voltage	Tolerance (±%)

NOTE 2 – SPECIAL SELECTIONS AVAILABLE INCLUDE:

(a) Nominal zener voltages between those shown.

(b) Matched sets: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%)

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

NOTE 3 – TYPICAL TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

a. I_{ZT} = 7.5 mA; $T_1 = 25^oC$.
$T_2 = 125^oC$ (MZ92-2,4A,B thru MZ92-12A,B).

b. I_{ZT} = Rated I_{ZT}, $T_1 = 25^oC$
$T_2 = 125^oC$ (MZ92-13A,B thru MZ92-200A,B)

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

NOTE 4 – $I_{Z(surge)}$ NON-REPETITIVE

The rating listed in the electrical characteristics table is maximum peak, non-repetitive, reverse surge current of 1/2 square wave or equivalent sine wave pulse of 1/120 second duration superimposed on the test current, I_{ZT}, per JEDEC registration.

2N... & 3N... JEDEC REGISTERED DEVICE SPECIFICATIONS

TRANSISTORS

- Amplifier
- Avalanche
- Chopper
- Light Sensitive
- Multiple Device
- Power
- Switching
- Unijunction

THYRISTORS & TRIGGERS

2N5016 (SILICON)

The RF Line

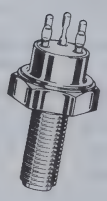
NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF and UHF power amplifier applications in military and industrial equipment. Suited for use in Class B or C amplifier applications to 600 MHz.

- High Power Output –
  P_{out} = 15 W (Min) @ f = 400 MHz
- Balanced Emitter Construction to Assure Ruggedness and Resist Transistor Damage Due to Load Mismatch
- Large-Signal Impedance Data Provided to Simplify Matching Network Design

15 W–400 MHz
RF POWER
TRANSISTOR

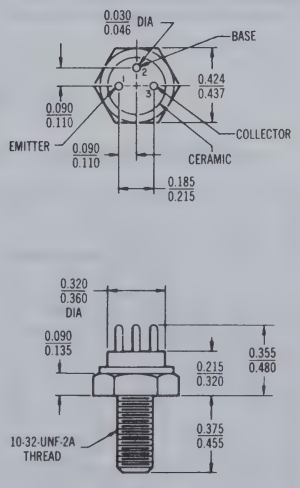
NPN SILICON



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	4.5	Adc
Base Current-Continuous	I_B	1.5	Adc
Total Device Dissipation @ T_C = 50°C Derate above 50°C	P_D	30 0.2	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 36
TO-60

Case Common to Emitter

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, R_{BE} = 30 ohms)	$V_{CER(sus)}$	40	–	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEV}	 – –	 – –	 10 10	mAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 4.0 Vdc) (I_C = 4.5 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	 10 3.0	 – –	 200 –	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (2) (I_C = 500 mAdc, V_{CE} = 15 Vdc, f = 400 MHz)	f_T	500	–	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f - 1.0 MHz)	C_{ob}	–	20	25	pF
FUNCTIONAL TEST					
Power Input (P_{out} = 15 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{in}	–	–	5.0	Watt
Collector Efficiency (P_{in} = 5.0 W, P_{out} = 15 W, V_{CC} = 28 Vdc, f = 400 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.

(1) Pulsed thru 25 mH Inductor @ 50% Duty Cycle.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 400 MHz POWER OUTPUT TEST CIRCUIT

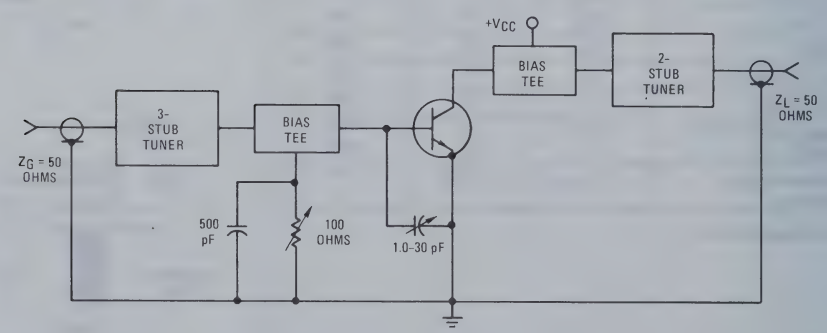


FIGURE 2 – POWER OUTPUT versus FREQUENCY

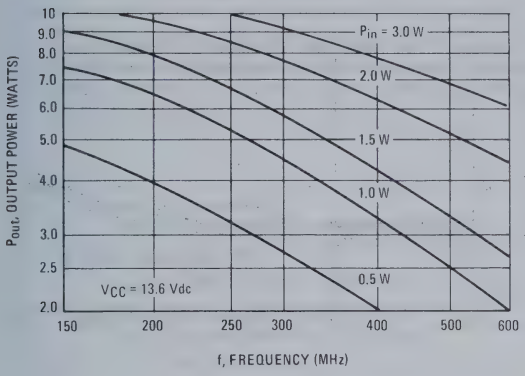


FIGURE 3 – POWER OUTPUT versus FREQUENCY

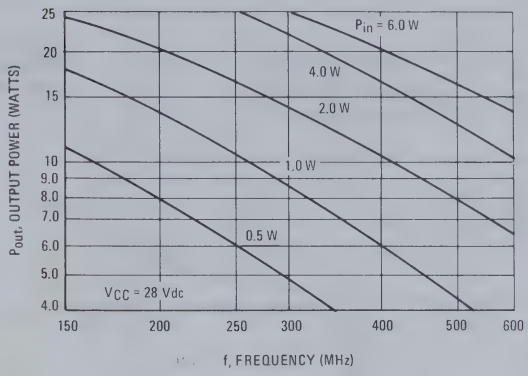


FIGURE 4 – POWER OUTPUT versus POWER INPUT

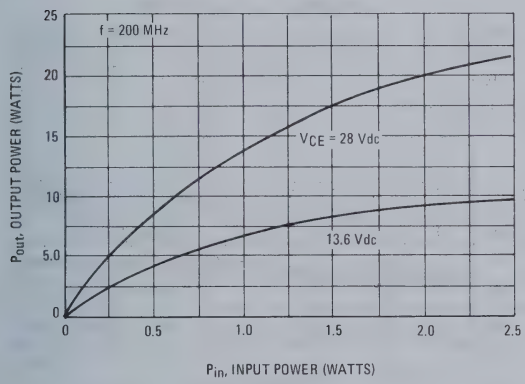


FIGURE 5 – POWER OUTPUT versus POWER INPUT

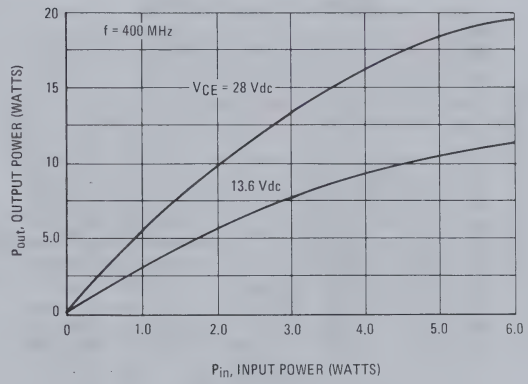


FIGURE 6 – POWER OUTPUT versus POWER INPUT

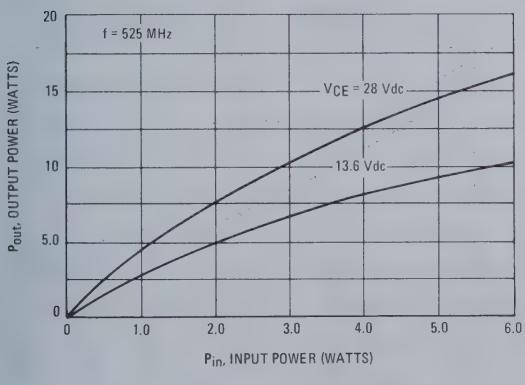
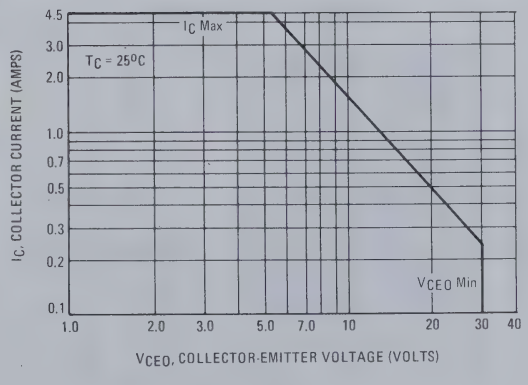


FIGURE 7 – DC SAFE OPERATING AREA



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8 – V_{CC} = 13.6 Vdc

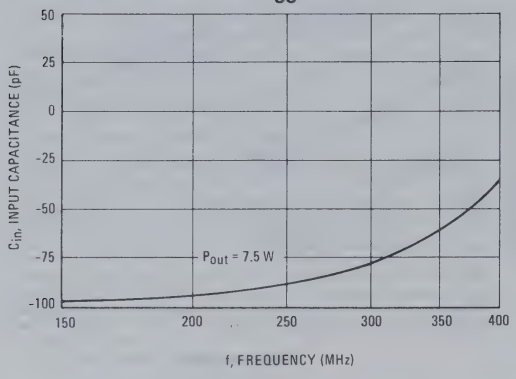
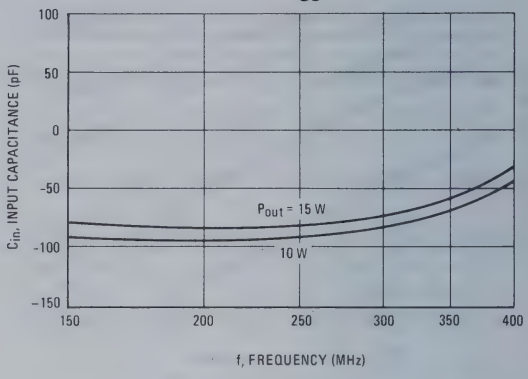


FIGURE 9 – V_{CC} = 28 Vdc



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 10 – V_{CC} = 13.6 Vdc

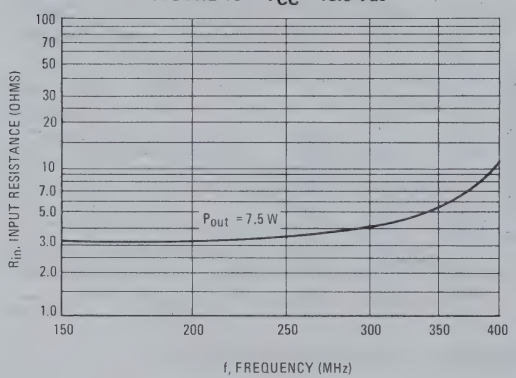
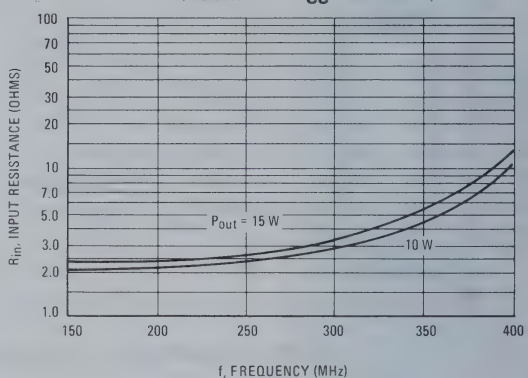


FIGURE 11 – V_{CC} = 28 Vdc



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 12 – V_{CC} = 13.6 Vdc

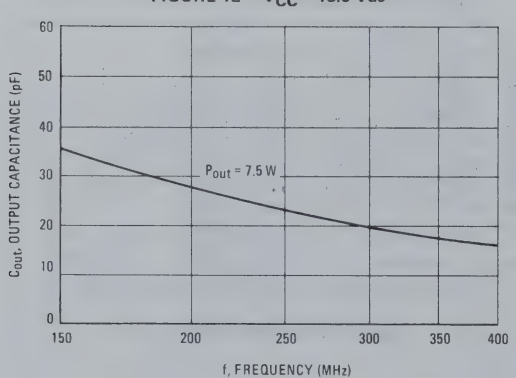
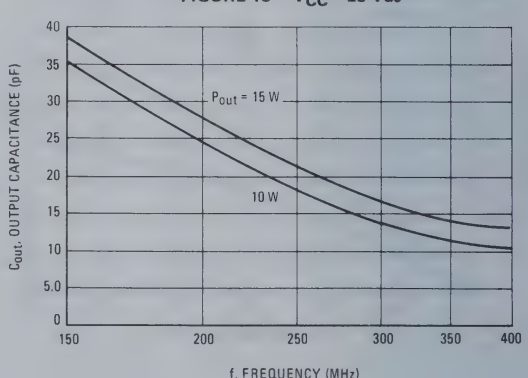


FIGURE 13 – V_{CC} = 28 Vdc



2N5031 (SILICON)
2N5032

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . . designed primarily for use in high-gain, low-noise, small-signal amplifiers in military and industrial equipment. Suitable for use in video wideband and general high-frequency amplifier applications of 50 to 1000 MHz.

- Low Noise Figure –
  NF = 2.5 dB (Max) @ f = 450 MHz (2N5031)
- High Power Gain –
  G_{pe} = 17 dB (Typ) @ f = 450 MHz
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Min) @ I_C = 5.0 mAdc

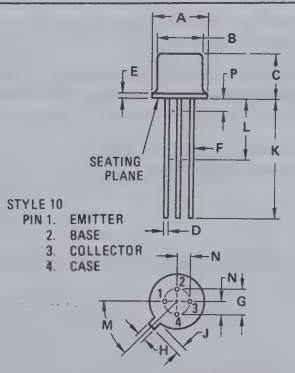
NPN SILICON RF SMALL-SIGNAL TRANSISTORS



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	10	–	–	Vdc
*Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
*Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.35	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.0	–	Vdc
DYNAMIC CHARACTERISTICS					
*Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1000	–	3500	MHz
*Output Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)	C_{cb}	–	1.3	1.5	pF
Collector-Base Time Constant (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	5.0	–	ps
*Noise Figure† (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz) 2N5031 2N5032	NF	– –	– –	2.5 3.0	dB
FUNCTIONAL TEST					
*Common-Emitter Amplifier Power Gain† (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 450 MHz)	G_{pe}	14	17	25	dB

*Indicates JEDEC Registered Data.
†Tuned for Minimum Noise.

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

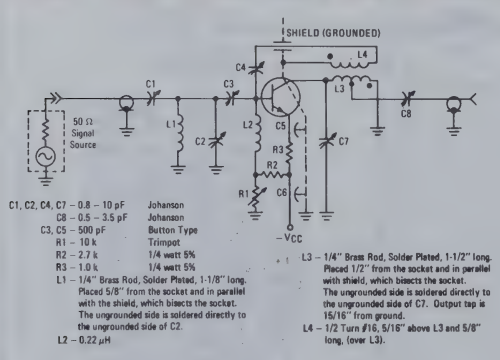


FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

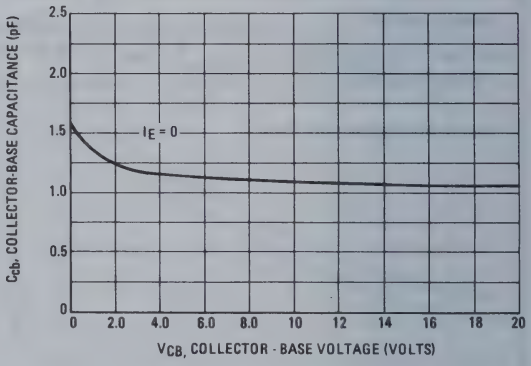


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

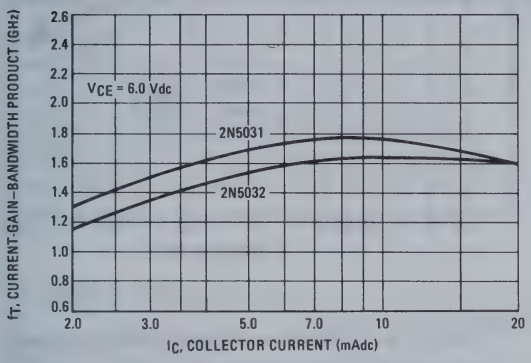


FIGURE 4 – S_{11} AND S_{22}

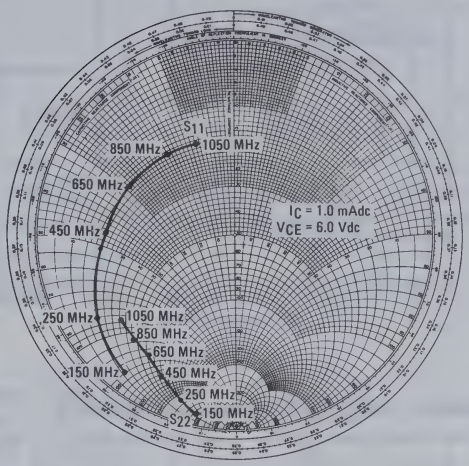


FIGURE 5 – S_{12}

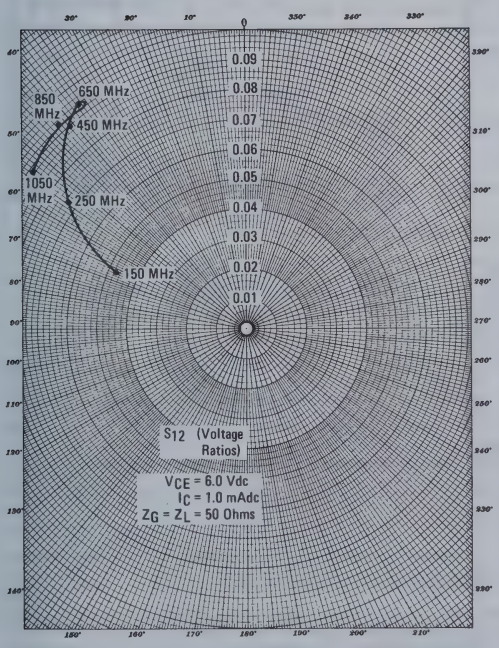


FIGURE 6 – S_{21}

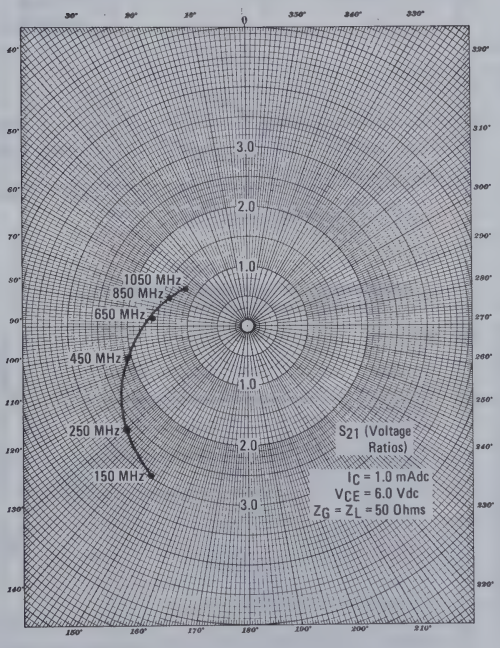


FIGURE 7 – NOISE FIGURE versus FREQUENCY

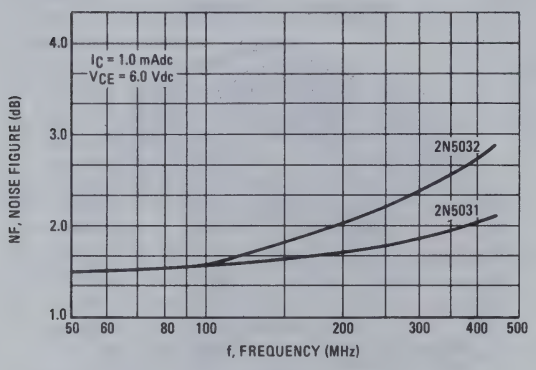


FIGURE 8 – POWER GAIN versus FREQUENCY

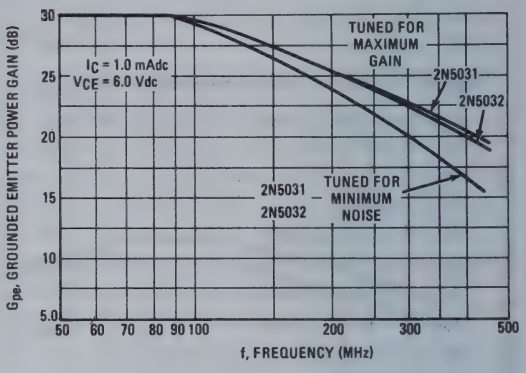


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

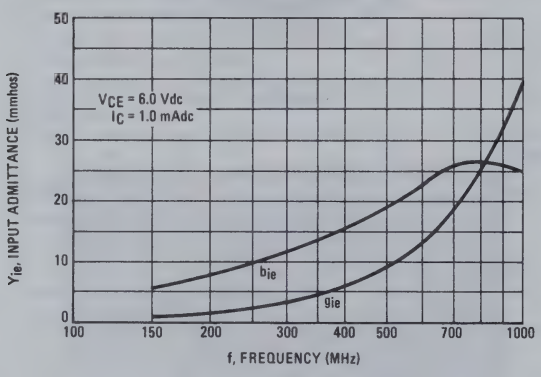


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

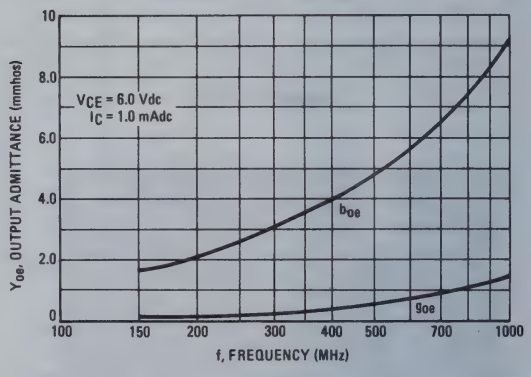


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

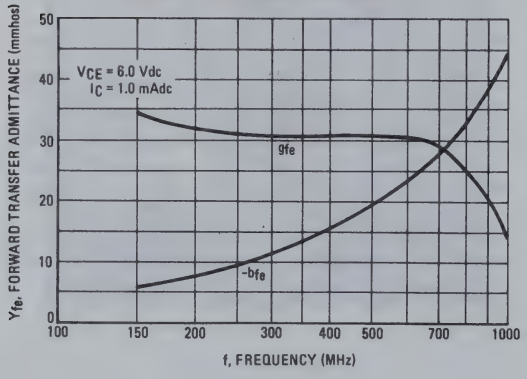
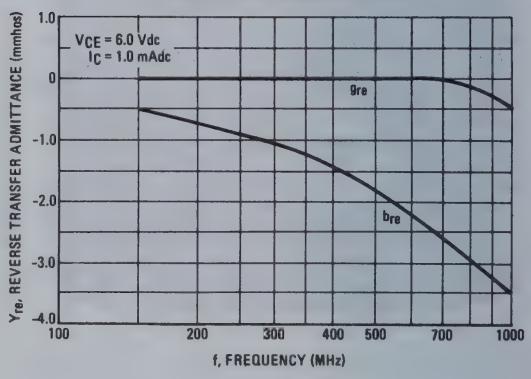


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



2N5050 (SILICON)
2N5051
2N5052

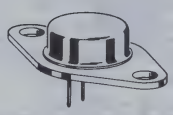
MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for untuned amplifier and switching applications.

- High Voltage Ratings —
  V_{CEO} = 125, 150 and 200 Vdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 0.75 Adc
- Packaged in the Compact, High Efficiency TO-66 Case

2 AMPERE POWER TRANSISTORS NPN SILICON

125-200 VOLTS
40 WATTS



*MAXIMUM RATINGS

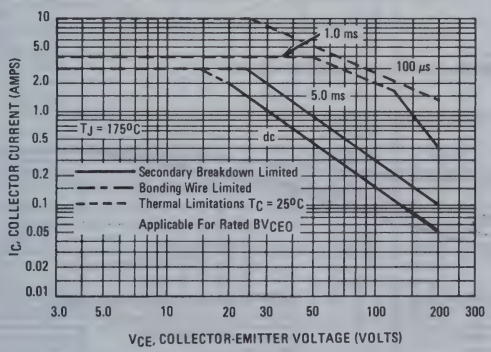
Rating	Symbol	2N5050	2N5051	2N5052	Unit
Collector-Emitter Voltage	V_{CEO}	125	150	200	Vdc
Collector-Base Voltage	V_{CB}	125	150	200	Vdc
Emitter-Base Voltage	V_{EB}	6.0			Vdc
Collector Current — Continuous	I_C	2.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.266			Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +175			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

*THERMAL CHARACTERISTICS

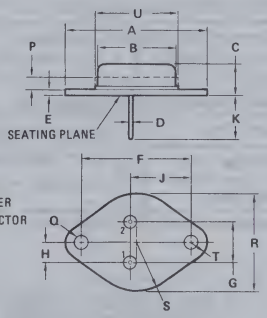
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.76	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.88	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

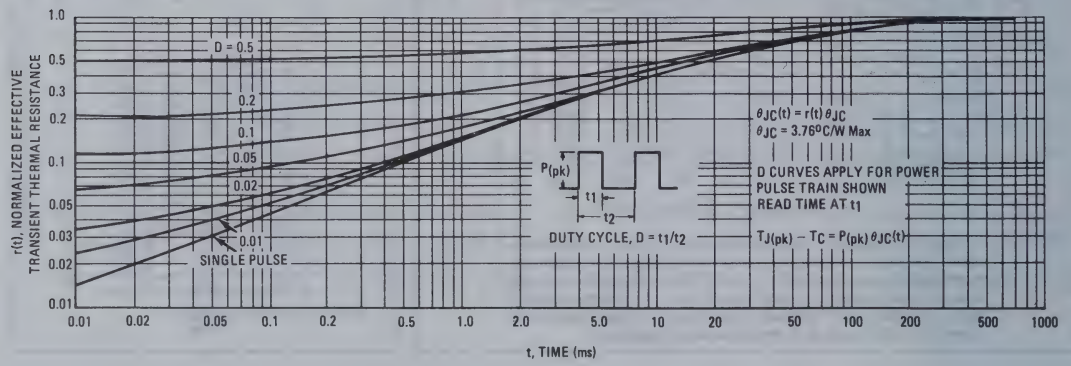
CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	2N5050	$V_{CEO(sus)}$	125	–	Vdc
	2N5051		150	–	
	2N5052		200	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 62.5 Vdc, I_B = 0)	2N5050		–	0.1	
(V_{CE} = 75 Vdc, I_B = 0)	2N5051		–	0.1	
(V_{CE} = 100 Vdc, I_B = 0)	2N5052		–	0.1	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			–	0.5	
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	mAdc
***ON CHARACTERISTICS**					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 0.75 Adc, V_{CE} = 5.0 Vdc)			25	100	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			25	–	
(I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 0.75 Adc, I_B = 0.1 Adc)			–	1.0	
(I_C = 2.0 Adc, I_B = 0.4 Adc)			–	5.0	
Base-Emitter On Voltage (Note 1) (I_C = 0.75 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
***DYNAMIC CHARACTERISTICS**					
Current-Gain–Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)		f_T	10	–	MHz
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–
Common Base Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	250	pF
***SWITCHING CHARACTERISTICS**					
Rise Time	(V_{CC} = 120 Vdc, I_C = 750 mAdc, R_L = 150 Ohms, I_{B1} = I_{B2} = 100 mAdc)	t_r	–	300	ns
Storage Time		t_s	–	3.5	μs
Fall Time		t_f	–	1.2	μs

*Indicates JEDEC Registered Data. Note 1: Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 2 – THERMAL RESPONSE



2N5060 (SILICON)
thru
2N5064



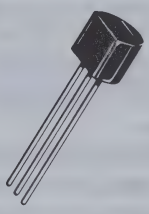
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for high volume consumer applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Sensitive Gate Trigger Current – 200 μA Maximum
- Low Reverse and Forward Blocking Current – 50 μA Maximum, T_C = 125°C
- Low Holding Current – 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity

PLASTIC SILICON CONTROLLED RECTIFIERS

0.8 AMPERE RMS
30 thru 200 VOLTS

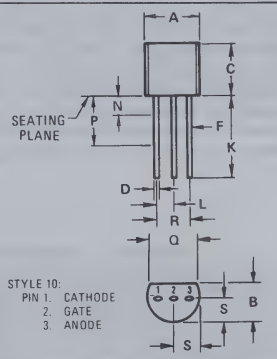


MAXIMUM RATINGS(1)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage 2N5060 2N5061 2N5062 2N5063 2N5064	V_{RRM}	 30* 60* 100* 150* 200*	Volts
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	0.8	Amp
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0*	Amp
Circuit Fusing Considerations, T_A = 25°C (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power – Forward, T_A = 25°C	P_{GM}	0.1*	Watt
Average Gate Power – Forward, T_A = 25°C	$P_{GF(AV)}$	0.01*	Watt
Peak Gate Current – Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	1.0*	Amp
Peak Gate Voltage – Reverse	V_{GRM}	5.0*	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +125*	°C
Storage Temperature Range	T_{stg}	-65 to +150*	°C
Lead Solder Temperature (<1/16" from case, 10 s max)	–	+230*	°C

*Indicates JEDEC Registered Data.

(1) Temperature reference point for all case temperatures in center of flat portion of package. (T_C = +125°C unless otherwise noted.)



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)		V_{DRM}			Volts
(T_C = 125°C)	2N5060		30*	–	
	2N5061		60*	–	
	2N5062		100*	–	
	2N5063		150*	–	
	2N5064		200*	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 125°C)		I_{DRM}	–	50*	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 125°C)		I_{RRM}	–	50*	μA
Forward "On" Voltage (Note 2) (I_{TM} = 1.2 A peak @ T_A = 25°C)		V_{TM}	–	1.7*	Volts
Gate Trigger Current (Continuous dc) (Note 3)	T_C = 25°C	I_{GT}	–	200	μA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	350*	
Gate Trigger Voltage (Continuous dc)	T_C = 25°C	V_{GT}	–	0.8	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	1.2*	
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms)	T_C = 125°C	V_{GD}	0.1	–	
Holding Current	T_C = 25°C	I_H	–	5.0	mA
(Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = -65°C		–	10*	
Thermal Resistance, Junction to Case (Note 4)		θ_{JC}	–	75*	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	200	°C/W

*Indicates JEDEC Registered Data.

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.
4. This measurement is made with the case mounted "flat side down" on a heat sink and held in position by means of a metal clamp over the curved surface.

FIGURE 1 – SURGE RATINGS

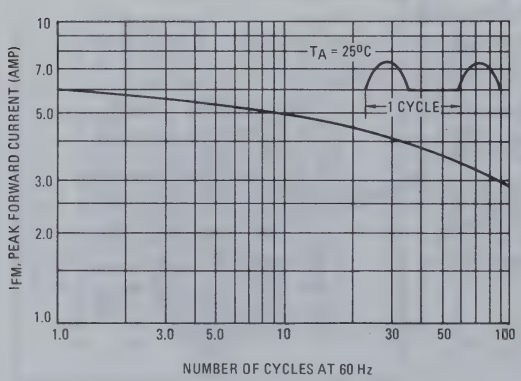


FIGURE 2 – POWER DISSIPATION

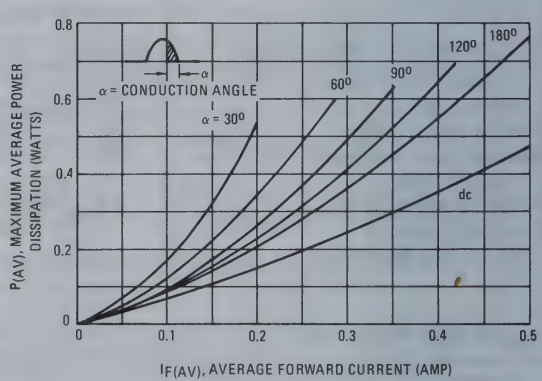


FIGURE 3 – FORWARD VOLTAGE

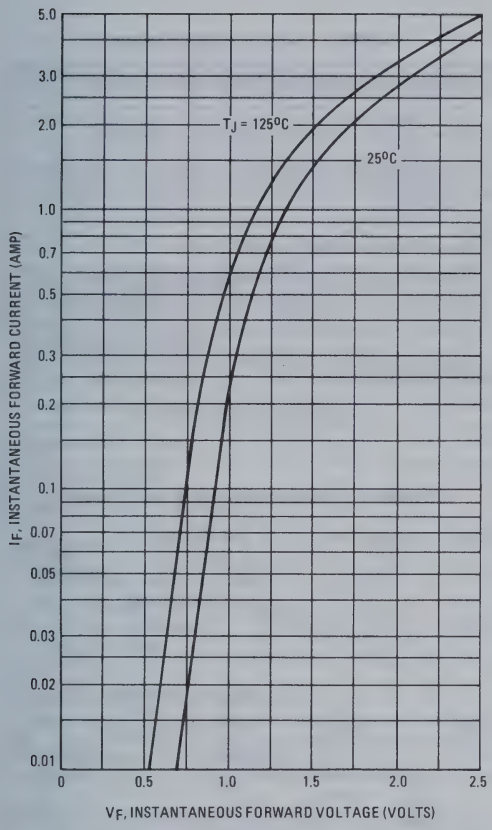


FIGURE 4 – CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

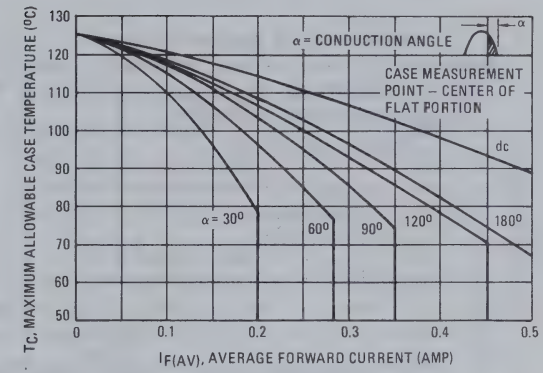


FIGURE 5 – CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE)

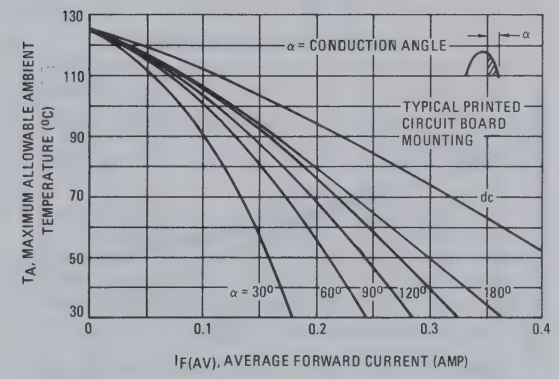
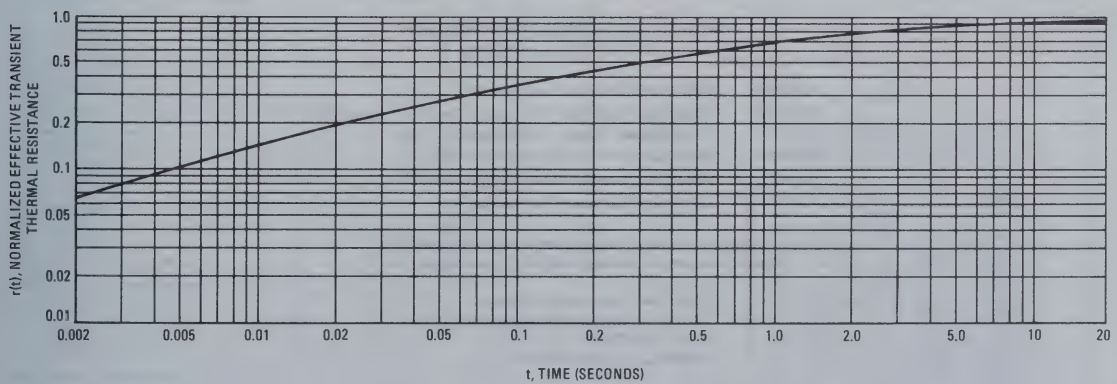


FIGURE 6 – THERMAL RESPONSE



TYPICAL CHARACTERISTICS

FIGURE 7 – GATE TRIGGER VOLTAGE

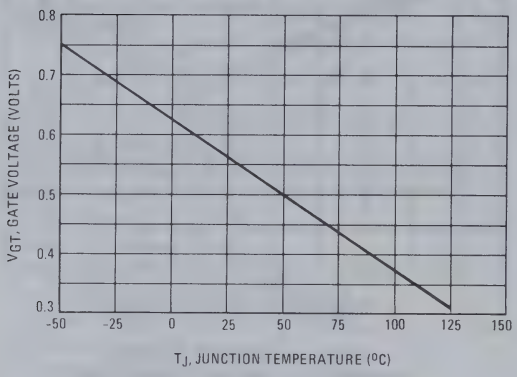


FIGURE 8 – GATE TRIGGER CURRENT

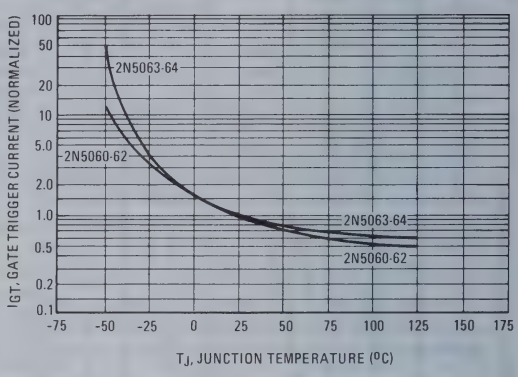


FIGURE 9 – HOLDING CURRENT

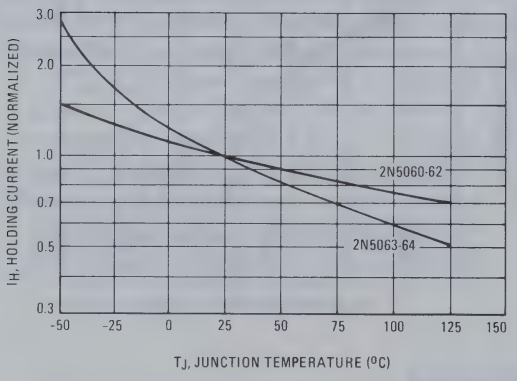
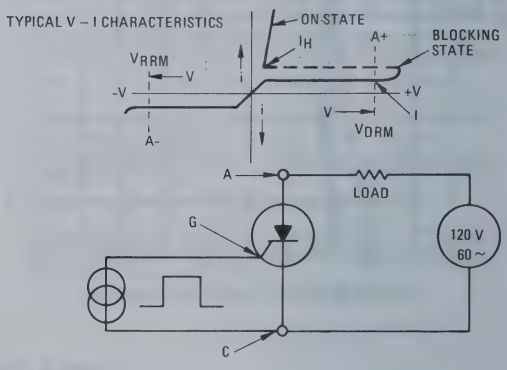


FIGURE 10 – CHARACTERISTICS AND SYMBOLS



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240 – SCR Power Control Fundamentals
AN-290B – Mounting Procedure for, and Thermal Aspects of, Thermopad Plastic Power Devices
AN-295 – Suppressing RFI in Thyristor Circuits
AN-422 – Testers for Thyristors and Trigger Diodes
AN-453 – Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

2N5067 (SILICON)
2N5068
2N5069

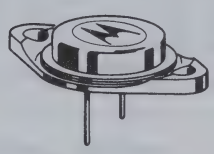
SILICON NPN POWER TRANSISTORS

. . . for use in power amplifier and switching circuits.

- Low Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc @ I_C = 1.0 Amp
- Excellent Safe Area Limits (Figure 11)
- Power Dissipation — P_D = 87.5 W @ T_C = 25°C
- Complement to PNP 2N4901, 2N4902, 2N4903

5 AMPERE POWER TRANSISTORS SILICON NPN

40-80 VOLTS
87.5 WATTS



MAXIMUM RATINGS

Rating	Symbol	2N5067	2N5068	2N5069	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current - Continuous	I_B	1.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 0.5			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

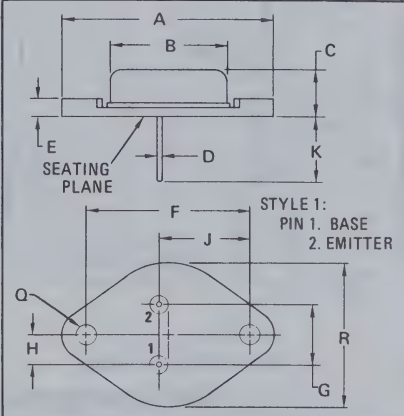
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.2 Adc, I_B = 0) 2N5067 2N5068 2N5069	11	$V_{CEO(sus)}$*	 40 60 80	 - - -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	5, 6	I_{CEX}	- -	1.0 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	5, 6	I_{CBO}	-	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}*	20 7.0	80 -	-
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 5.0 Adc, I_B = 1.0 Adc)	2, 3, 4	$V_{CE(sat)}$*	- -	0.4 1.5	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$*	-	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

* Pulse Test, PW = 300 μs, Duty Cycle = 2.0%



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector Connected to Case

CASE 11-03

FIGURE 1 — NORMALIZED DC CURRENT GAIN

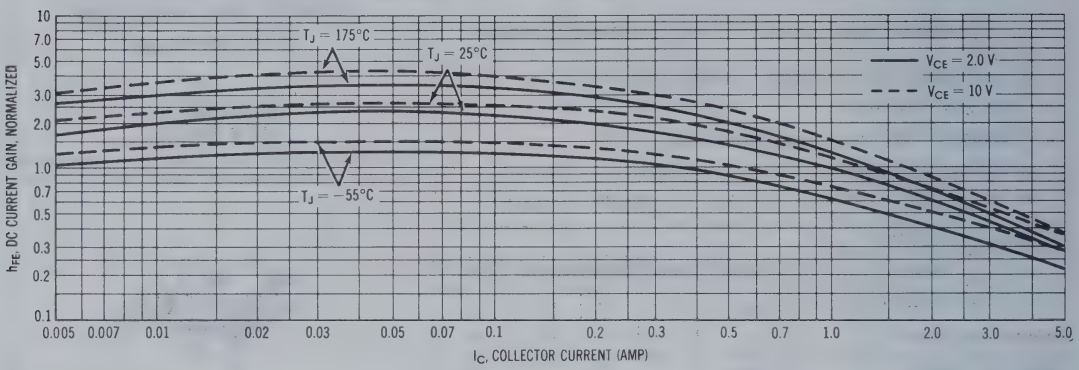


FIGURE 2 — COLLECTOR SATURATION REGION

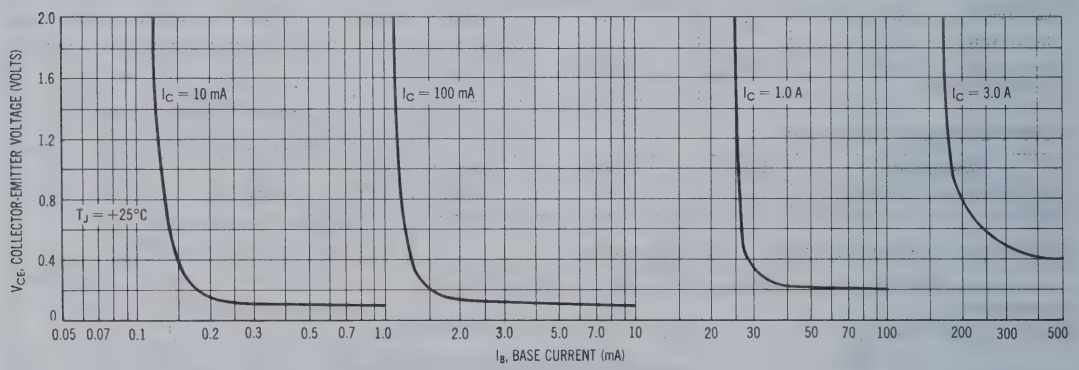


FIGURE 3 — "ON" VOLTAGES

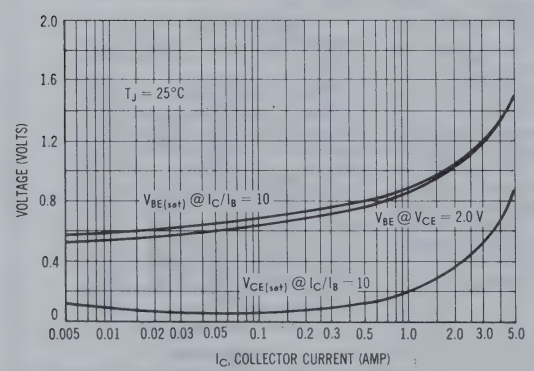
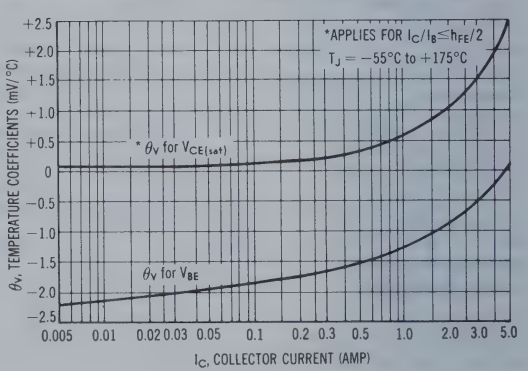


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

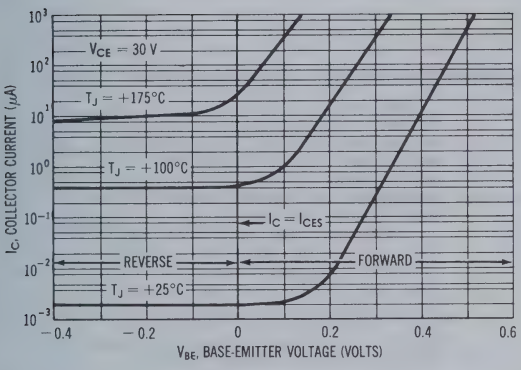


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

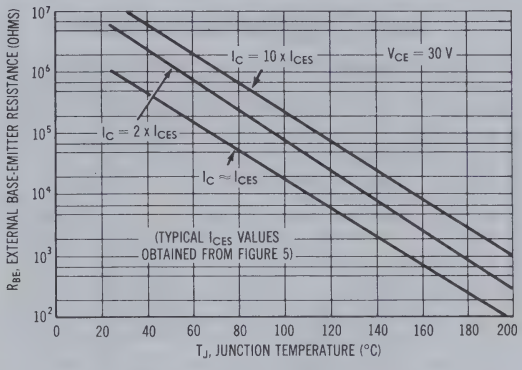


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

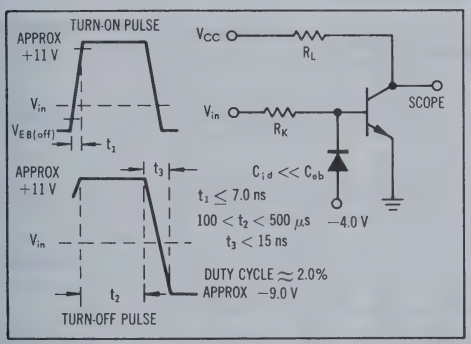


FIGURE 8 — CAPACITANCE

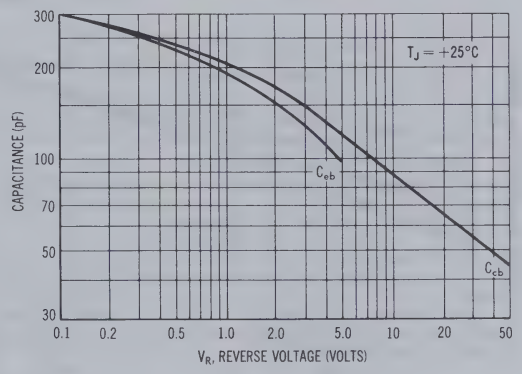


FIGURE 9 — TURN-ON TIME

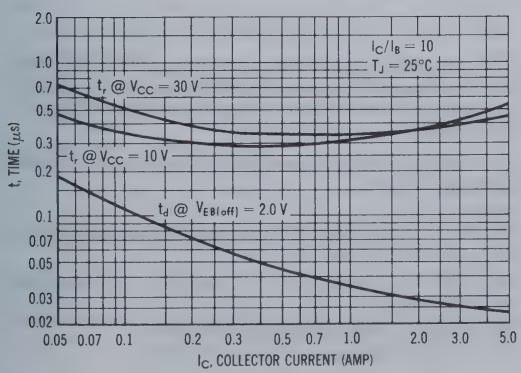
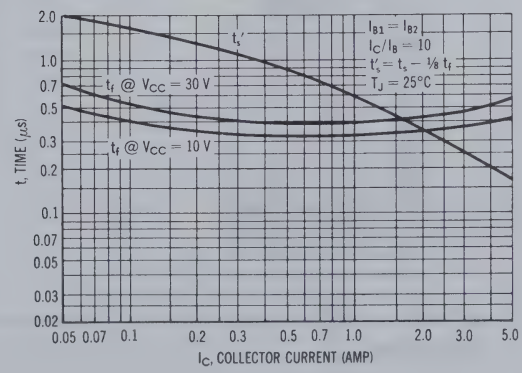
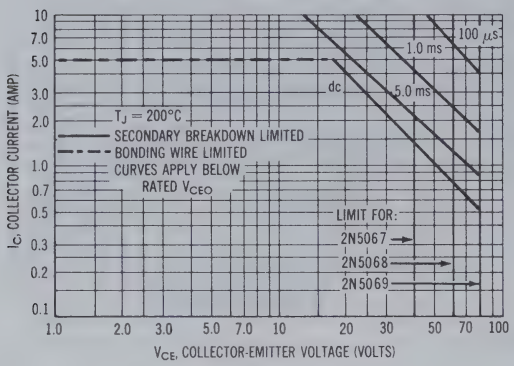


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

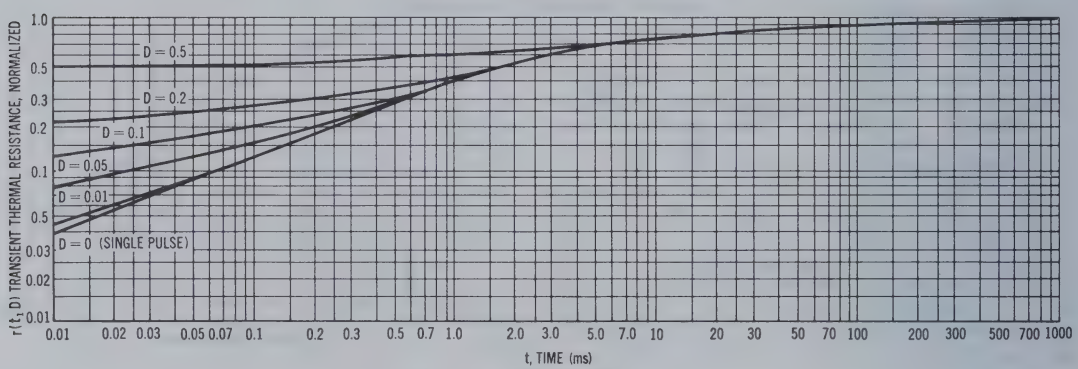
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

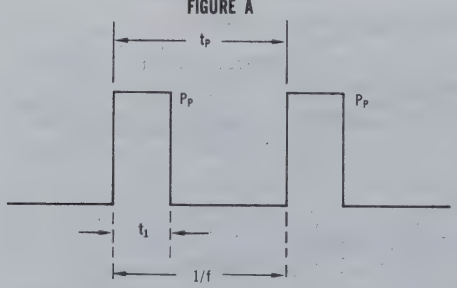
The data of Figure 11 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_P

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal reponse, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N5067 is dissipating 100 watts under the following conditions: t_1 = 0.1 ms, t_P = 0.5 ms. (D = 0.2)

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r (t_1, D) is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.28 \times 100 \times 2.0 = 56°C$$

2N5070 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

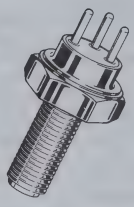
. . . designed primarily for applications as a high-power linear amplifier from 2.0 to 75 MHz.

- Optimized for Operation from a 28-Volt Supply
- Power Out @ 28 Vdc, 30 MHz – 25 W (PEP)
- Intermodulation Distortion at 25 W (PEP)
  IMD = 30 dB (Max)
- Isothermal-Resistor Design Results in Rugged Device

25 W (PEP) – 30 MHz

RF POWER TRANSISTOR

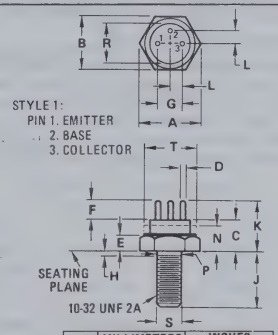
NPN SILICON



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous Peak	I_C	3.3 10	Adc
Base Current – Continuous	I_B	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	70 400	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.57	13.08	0.495	0.515
B	10.77	11.10	0.424	0.437
C	5.46	8.13	0.215	0.320
D	0.762	1.17	0.030	0.046
E	2.29	3.43	0.090	0.135
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	9.53	11.56	0.375	0.455
K	9.02	12.19	0.355	0.480
L	2.29	2.79	0.090	0.110
N	–	4.19	–	0.165
P	4.14	4.80	0.163	0.189
R	8.13	9.14	0.320	0.360
T	9.14	11.10	0.360	0.437

All JEDEC dimensions and notes apply

Emitter connected to case

CASE 36
TO-60

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

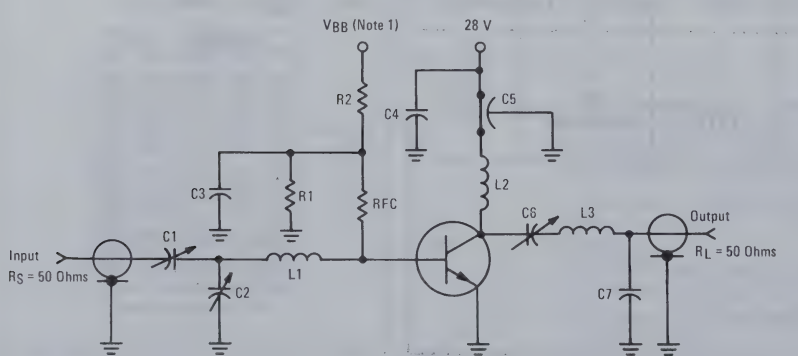
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, R_{BE} = 5.0 ohms)	$V_{CER(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	5.0	mAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = –1.5 Vdc) (V_{CE} = 60 Vdc, V_{BE} = –1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	10 10	mAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	10	mAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10 10	100 100	–
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product(2) (I_C = 1.0 Adc, V_{CE} = 15 Vdc, f = 50 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	85	pF
FUNCTIONAL TEST (Figure 1)				
Power Input (P_{out} = 25 W (PEP), Z_G = 50 Ohms, V_{CE} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	P_{in}	–	1.25	Watt (PEP)
Collector Efficiency (P_{out} = 25 W (PEP), Z_G = 50 Ohms, V_{CE} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	η	40	–	%
Intermodulation Distortion (P_{out} = 25 W (PEP), Z_G = 50 Ohms, V_{CE} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IMD	–	-30	dB

*Indicates JEDEC Registered Data.

(1)Pulsed thru 25 mH Inductor, Duty Cycle = 50%, Repetition Rate = 60 Hz.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 30 MHz LINEAR TEST CIRCUIT



L1: 3 Turns No. 12 AWG, 1/4" I.D., 1/2" Long
L2: 6 Turns No. 14 AWG, 3/8" I.D., 3/4" Long
L3: 5 Turns No. 10 AWG, 3/4" I.D., 3/4" Long
C1: 140-680 pF, ARCO 468 or Equivalent
C2: 170-780 pF, ARCO 469 or Equivalent
C3: 0.05 μF, Ceramic Capacitor
C4: 0.1 μF, Ceramic Capacitor
C5: 1000 pF, Feedthrough Capacitor
C6: 24-200 pF, ARCO 425, or Equivalent
C7: 32-250 pF, ARCO 426, or Equivalent
Q: 2N5070
R1: 1.0 Ω, 5.0 W
R2: 50 Ohms, 25 W
RFC: 350 Ferrite Choke, Ferroxcube* #VK200 01-03B, or Equivalent

*Ferroxcube Corp. of America, Saugerties, N. Y.

Note 1: Adjust V_{BB} for a collector quiescent current of 20 mA with no RF input signal.

FIGURE 2 – LINEAR OUTPUT POWER versus FREQUENCY

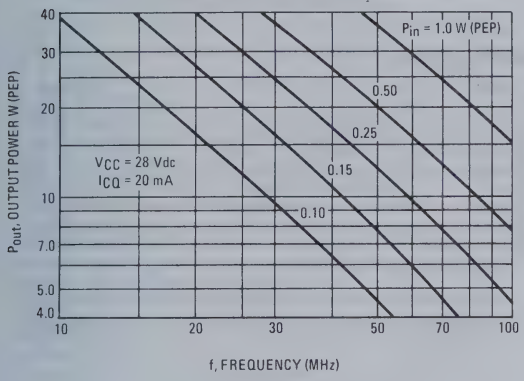


FIGURE 3 – TYPICAL OUTPUT POWER versus INPUT POWER

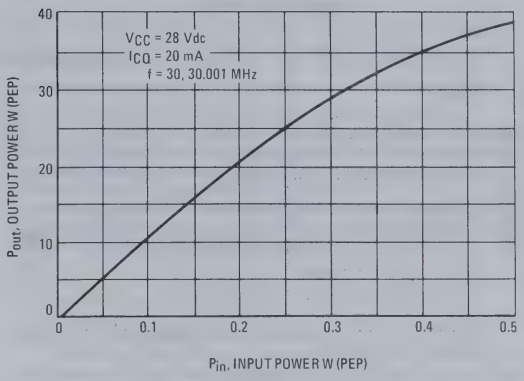


FIGURE 4 – TYPICAL OUTPUT POWER versus INPUT POWER

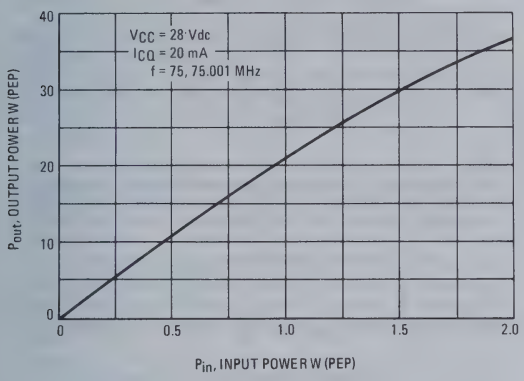
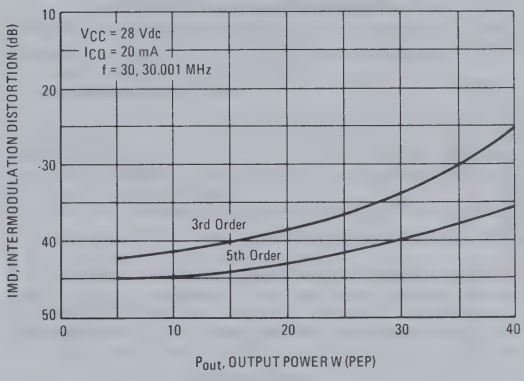


FIGURE 5 – TYPICAL INTERMODULATION DISTORTION versus OUTPUT POWER



LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

FIGURE 6 – f = 30 MHz

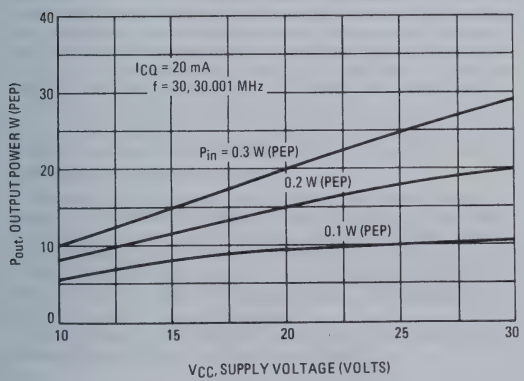


FIGURE 7 – IMD = -30 dB

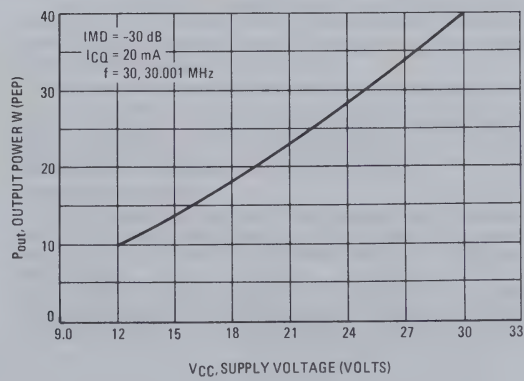


FIGURE 8 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

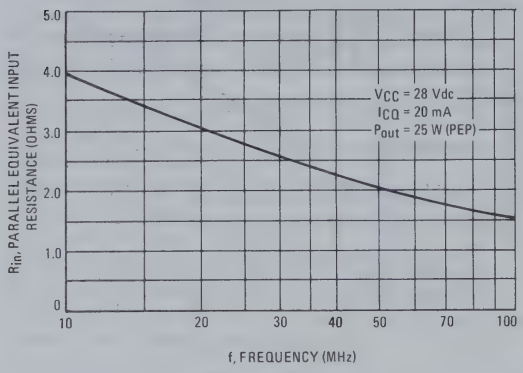


FIGURE 9 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

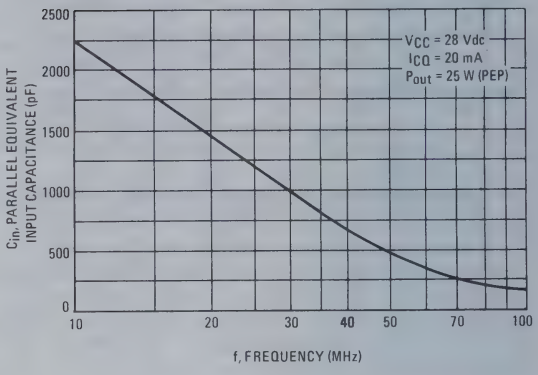


FIGURE 10 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

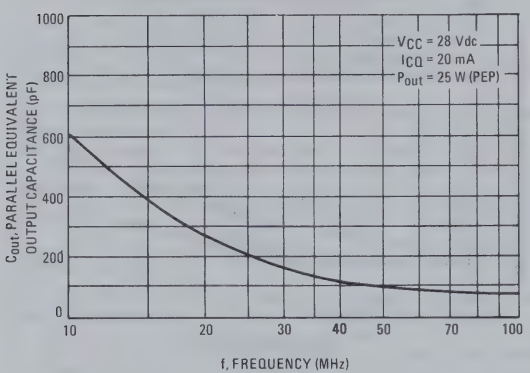
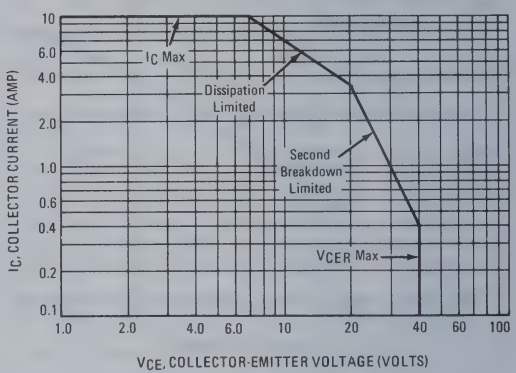


FIGURE 11 – DC SAFE OPERATING AREA



APPLICATIONS INFORMATION

The 2N5070 transistor is designed for linear power amplifier operation in the HF/VHF region (2 to 75 MHz). It features guaranteed linear amplifier performance rather than the conventional performance demonstrated in a class C* amplifier.

Class C operation is inherently non-linear, but in many power amplifier applications non-linear operation does not present major problems. With a single frequency driving signal, the only spurious signals generated are harmonics and these can be suppressed in the amplifier tuned networks and output filter.

For single sideband (SSB), low level amplitude modulation (AM), and other types of complex signals, class C operation is generally not satisfactory. For instance, when a signal contains multiple frequencies at close spacings, odd-order non-linearities will generate spurious outputs which are within the passband of the tuned circuits and filters; therefore, the spurious outputs are not suppressed before they reach the antenna or other load. As a result, such complex signals require linear amplification if the amplified signal is to be free of spurious outputs.

A detailed analysis of spurious signals generated by non-linearities and linearity requirements of various applications is described in Chapter 12 of Reference 1.

The following discussion concerns itself with a detailed description of the 2N5070 characterization curves and general information on solid state linear power amplifier design.

The Two-Tone Test

The 2N5070 functional test specification consists of a linear power amplifier test with guaranteed limits on power output, gain, efficiency, and intermodulation distortion (IMD) output levels. A two-tone test signal is used with the test amplifier as shown in Figure 1.

The two-tone test is one of many methods commonly used for testing linear amplifier performance. This test involves driving the amplifier with two RF signals, of equal amplitude, separated in frequency from each other by approximately 1 kHz.

When a two-tone test signal consisting of frequencies f_1 and f_2 is passed through a non-linear amplifier, odd order non-linearities generate spurious signals near the desired carrier. The level of these spurious signals provides a measure of the degree of non-linearity of the amplifier. This type of non-linearity is called intermodulation distortion (IMD). The spurious signals generated by IMD are further classified according to the exponential order of the amplifier non-linearity, i.e., 3rd order IMD products, 5th order IMD products, etc. The 3rd and 5th order IMD products are usually the most significant encountered with linear power amplifiers. Data on both 3rd and 5th order IMD are included in the 2N5070 characterization.

Third order IMD generates spurious signals near the operating frequency at frequencies $2f_1 - f_2$ and $2f_2 - f_1$; and 5th order IMD spurious signals are at frequencies $3f_1 - 2f_2$ and $3f_2 - 2f_1$.

Specifications and Characterization

The two-tone functional amplifier test is performed in a manner identical to the conventional class C functional test with two exceptions: a two-frequency signal is used in place of a single frequency, and amplifier linearity is added to the items tested and specified.

The functional test procedure for the 2N5070 requires driving the test amplifier with a two frequency signal and measuring power output, gain, efficiency, and linearity.

Power output, gain, and efficiency measurement methods are the same for both linear and class C amplifiers.

Since a multiple frequency test signal has an instantaneous power level which varies with time, power levels are normally expressed in peak envelope power (PEP). This is the average power level of the envelope at its greatest amplitude point.

When the test signal consists of multiple signals with equal amplitudes and different frequencies, the relationship of average power and PEP is given by the following expression:

$$\text{Average power} = \frac{\text{PEP}}{N}$$

where N = the number of input frequencies.

Therefore, when measuring the power level of a standard two-tone test signal, a true average reading power meter will indicate 1/2 the PEP of the signal.

Linearity is tested by measuring the amplitudes of the 3rd and 5th order IMD products. The ratio of one of the 3rd order products to one of the two desired frequencies is then expressed as a power ratio in decibels (dB). This is repeated for the 5th order products. The smaller of these two ratios (usually the 3rd order) is then included in the electrical characteristics specification as intermodulation distortion ratio (IMD).

2N5070 Performance Curves

Figures 2 through 4 show typical power output and gain characteristics versus frequency and/or input power. These curves are similar to those found on other RF power transistor data sheets with one exception, a two-frequency test signal was used rather than a single frequency signal.

The curves shown in Figure 5 are unique to transistors characterized for linear power amplifier service and show the typical IMD levels versus power output.

The 2N5070 features guaranteed IMD performance at the -30 dB level. However, the designer may desire IMD greater or less than -30 dB for a particular application. Figure 5 provides data on IMD levels that can be expected as a function of output power.

Figure 6 shows the variation in gain with dc supply voltage and provide data on gain only. It does not include information on IMD ratio.

Figure 7 reflects the power output that can be obtained at a fixed IMD ratio for operation with dc supply voltages other than 28 Vdc.

Figures 8 through 10 show the large signal impedance characteristics of the 2N5070. These are similar to curves shown on other Motorola data sheets except a two-frequency test signal was used rather than a single frequency signal.

It must be stressed that the data shown in Figures 8 through 10 do not represent y, z, h, s, or any standard two-port parameter set. The actual transistor impedance levels during normal operation in an amplifier are given. For a detailed discussion of RF power transistor large signal impedance, see Reference 2.

Linear Amplifier Design

The following is a discussion of some general design considerations for solid-state linear power amplifiers. While this is not a detailed analysis of linear amplifier design, some general guidelines are provided.

The major difference between linear power amplifiers and class C power amplifiers is in the dc bias circuitry. As stated in the introduction, class C operation usually involves a collector dc supply as

APPLICATIONS INFORMATION (continued)

the only bias voltage with $V_E = V_B = 0$. The collector current is zero until the input RF signal turns the transistor "on".

In contrast, a linear amplifier is normally operated with forward bias and some collector current flowing when no signal is present.

The magnitude of no-signal collector current and the bias circuitry may vary with the application. Optimum no-signal collector current for the 2N5070 was found to be approximately 20 mA.

The key to bias circuitry for good linearity lies in maintaining the base-emitter dc voltage relatively constant as the RF signal amplitude varies. The inherent nature of a forward-biased RF power transistor is to bias itself "off" with increasing RF drive signal. Therefore, a constant voltage source is required for base voltage.

Temperature effects also complicate the situation, since V_{BE} decreases with increasing temperature.

A simple solution to the bias problem involves the use of a forward-biased diode mounted on the transistor heat sink for thermal coupling to the transistor. A large capacitor (several hundred microfarads) in parallel with the diode helps maintain a constant V_{BE} with RF drive and improves linearity, while the diode provides temperature compensation to prevent thermal runaway. It is also possible to use complex active circuitry for biasing, and some rather exotic schemes have been developed to provide the same results.

Another important consideration is the collector-output network. Normally, a network with low impedance to ground for harmonics provides better linearity than a network with high harmonic impedances; therefore, some experimentation with network configuration is in order. Proper impedance matching remains the primary factor in both input and output network design. Further, it must also be stressed that the collector load impedance should be designed for the PEP, not the average power output. See Chapter 13 of Reference 1 for a detailed discussion of network design considerations.

Feedback may also be employed to improve linearity and may take the form of either neutralization or negative RF feedback. The possibilities here are limited only by the designer's imagination. Of course, negative RF feedback involves a decrease in gain to improve linearity.

REFERENCES

1. Pappenfus, Bruene, Schoenike, "Single Sideband Principles and Circuits", McGraw-Hill.
2. Hejhall, "Systemizing RF Power Amplifier Design", Motorola Semiconductor Products Inc., Application Note AN-282.

*"Class C", as used here refers to operation with the no signal conditions $I_C = 0$, and $V_{BE} = 0$, and a theoretical conduction angle of less than 180°, even though the actual conduction angle may be more than 180°.

2N5086 (SILICON)
2N5087

PNP SILICON ANNULAR TRANSISTORS

. . . PNP silicon annular transistors designed for low-level, low-noise amplifier applications.

- High Breakdown Voltage — BV_{CEO} = 50 V min
- Low 1.0 kHz Noise Figure —
  2N5086 — 3.0 dB max
  2N5087 — 2.0 dB max
- High Gain at Low Current —
  2N5087 — 250 @ 100 μAdc
- Low Current-Gain — Bandwidth Product to Facilitate Audio Frequency Design — f_T = 130 MHz typ
- Low Leakage Current — I_{CBO} = 10 nAdc max @ 10 V
- Low Capacitance — C_{ob} = 4.0 pF max

PNP SILICON AMPLIFIER TRANSISTORS



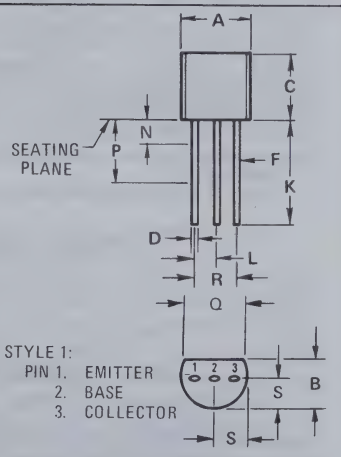
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

*Indicates JEDEC Registered Data



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS T_A = 25°C unless otherwise noted

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	10	nAdc
(V_{CB} = 35 Vdc, I_E = 0)			-	-	50	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5086	h_{FE}	150	-	500	-
	2N5087		250	-	800	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5086		150	-	-	
	2N5087		250	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5086		150	-	-	
	2N5087		250	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc		$V_{BE(on)}$	-	-	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	2N5086	f_T	40	120	-	MHz
	2N5087		40	150	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5086	h_{fe}	150	-	600	-
	2N5087		250	-	900	
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	2N5086	NF	-	-	3.0	dB
	2N5087		-	-	2.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	2N5086		-	1.2	3.0	
	2N5087		-	1.0	2.0	

NOISE FIGURE
V_{CE} = 5.0 Vdc, T_A = 25

FIGURE 1 — FREQUENCY EFFECTS

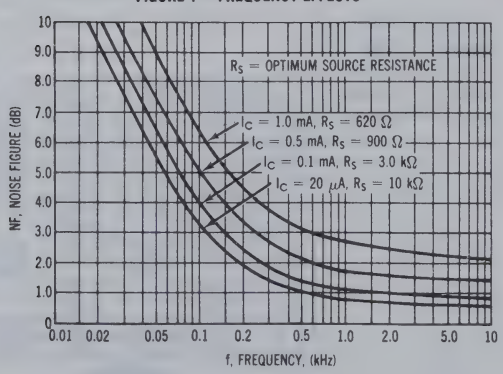
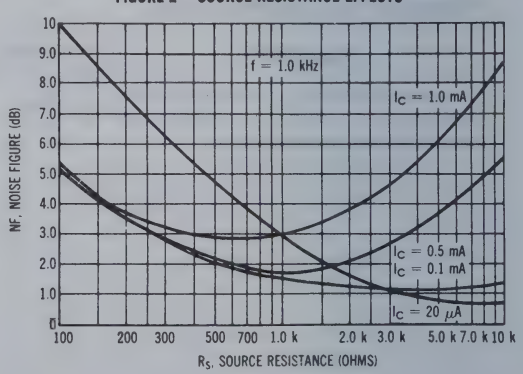


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C
(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE

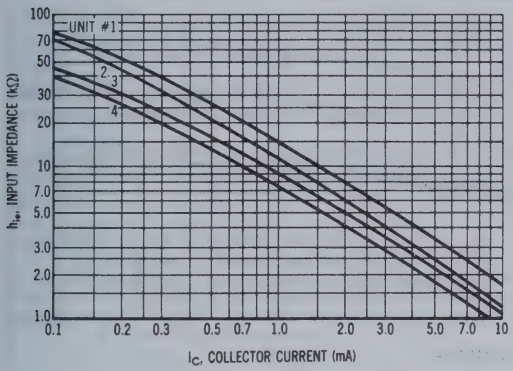


FIGURE 4 — VOLTAGE FEEDBACK RATIO

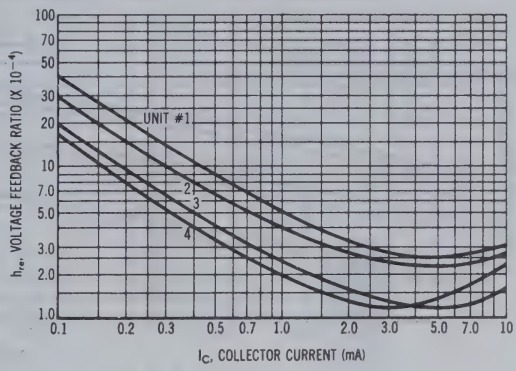


FIGURE 5 — CURRENT GAIN

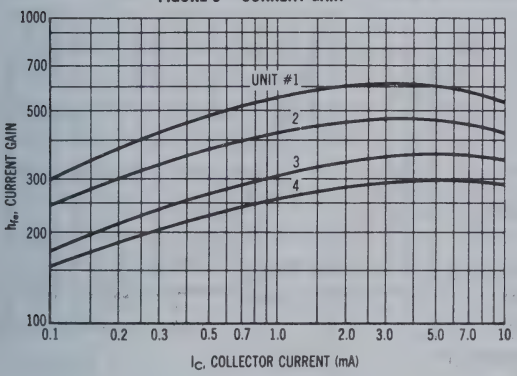


FIGURE 6 — OUTPUT ADMITTANCE

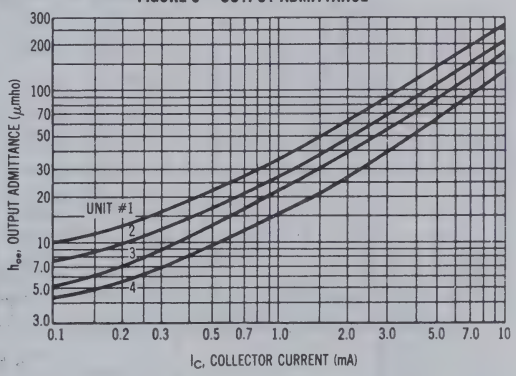


FIGURE 7 — EFFECT OF VOLTAGE

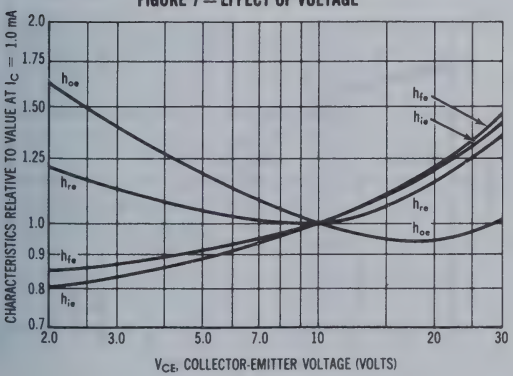


FIGURE 8 — DETERMINANT

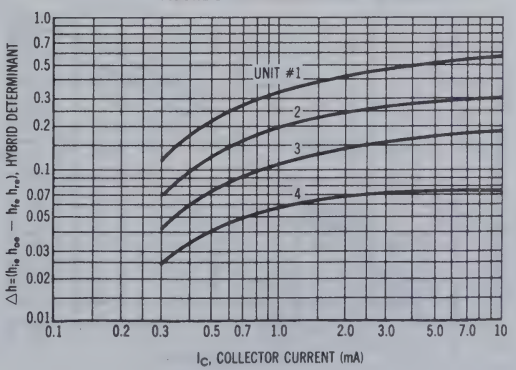


FIGURE 9 — DC CURRENT-GAIN

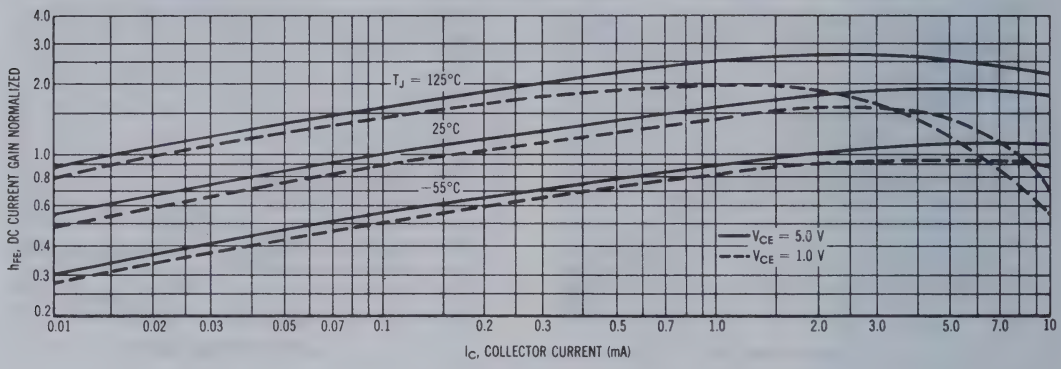


FIGURE 10 — COLLECTOR SATURATION REGION

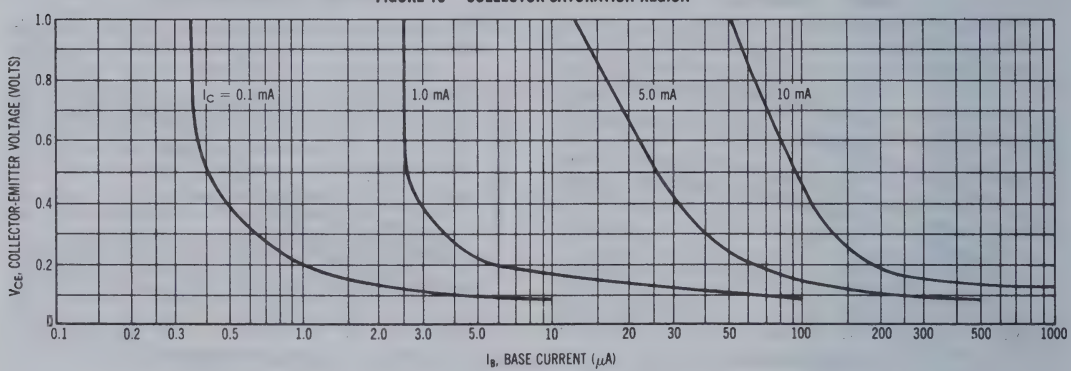


FIGURE 11 — CURRENT-GAIN — BANDWIDTH PRODUCT

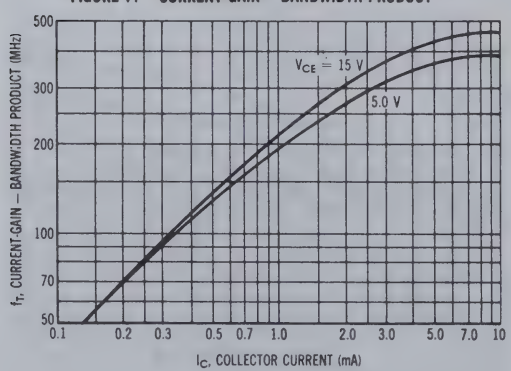
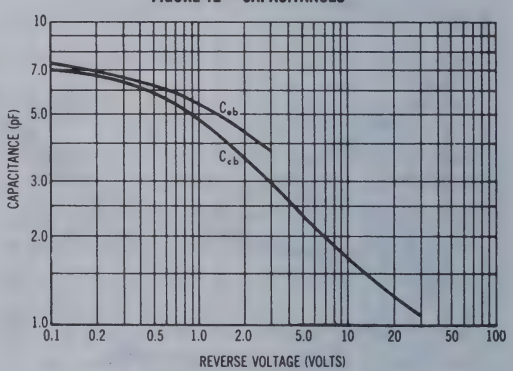


FIGURE 12 — CAPACITANCES



2N5088 (SILICON)
2N5089

NPN SILICON ANNULAR TRANSISTORS

. . . NPN silicon annular transistors designed for low-level, low- noise amplifier applications.

- High Gain at Low Current —
  2N5088 — 300 min at 100 μAdc
  2N5089 — 400 min at 100 μAdc
- Low 100 μAdc Noise Figure —
  1.2 dB typ at 100 Hz
  1.0 dB typ at 1.0 kHz
- Excellent Gain Linearity from 20 μAdc to 2.0 mAdc (See Figure 9)

NPN SILICON AMPLIFIER TRANSISTORS

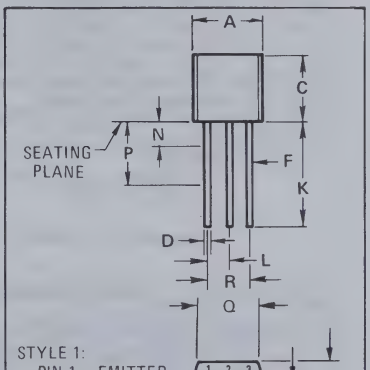


MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	35	30	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	2N5088	BV_{CEO}	30	-	-	Vdc
	2N5089		25	-	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5088	BV_{CBO}	35	-	-	Vdc
	2N5089		30	-	-	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	2N5088	I_{CBO}	-	-	50	nAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N5089		-	-	50	
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)			-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5088	h_{FE}	300	-	900	
	2N5089		400	-	1200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088		350	-	-	
	2N5089		450	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5088		300	-	-	
	2N5089		400	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz		f_T	50	175	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz, emitter guarded)		C_{cb}	-	1.8	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)		C_{eb}	-	4.0	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5088	h_{fe}	350	-	1400	-
	2N5089		450	-	1800	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz	2N5088	NF	-	-	3.0	dB
	2N5089		-	-	2.0	

NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25 °C

FIGURE 1 — FREQUENCY EFFECTS

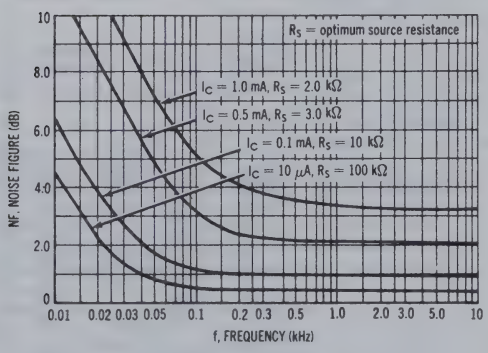
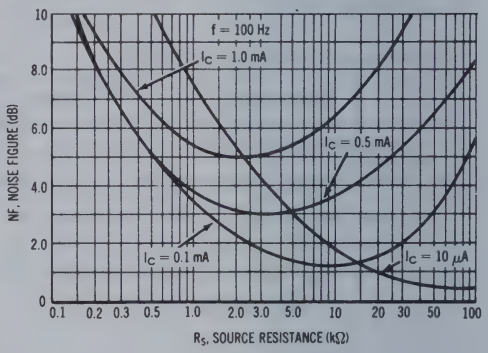


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C
(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE

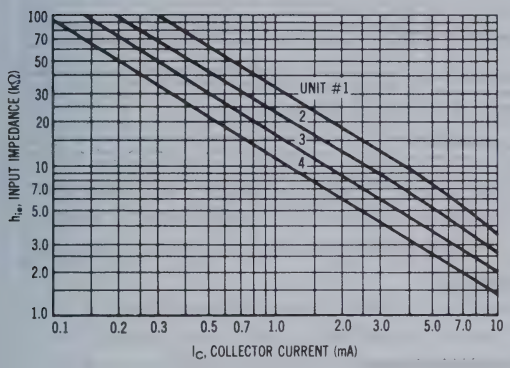


FIGURE 4 — VOLTAGE FEEDBACK RATIO

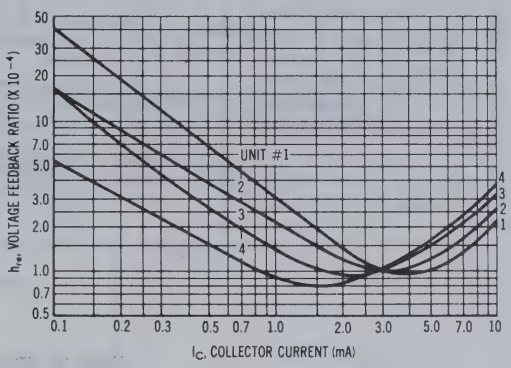


FIGURE 5 — CURRENT GAIN

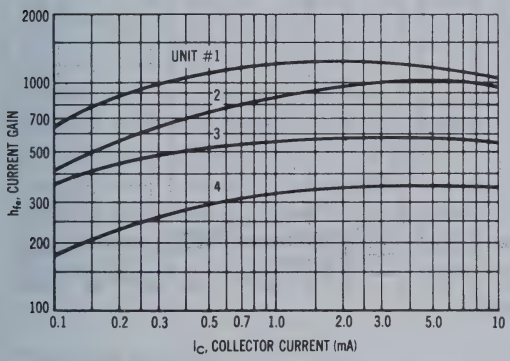


FIGURE 6 — OUTPUT ADMITTANCE

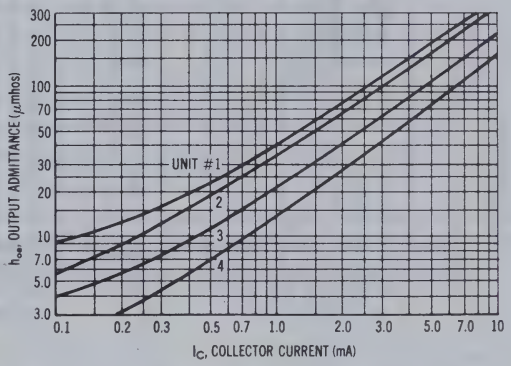


FIGURE 7 — EFFECT OF VOLTAGE

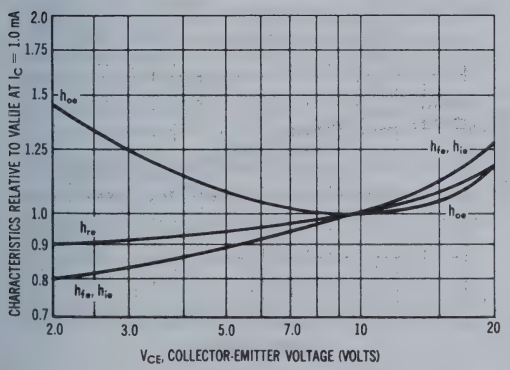


FIGURE 8 — DETERMINANT

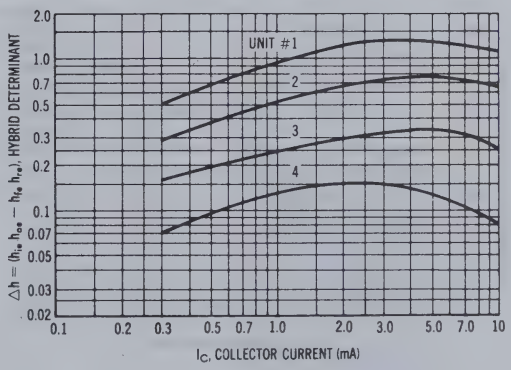


FIGURE 9 — DC CURRENT GAIN

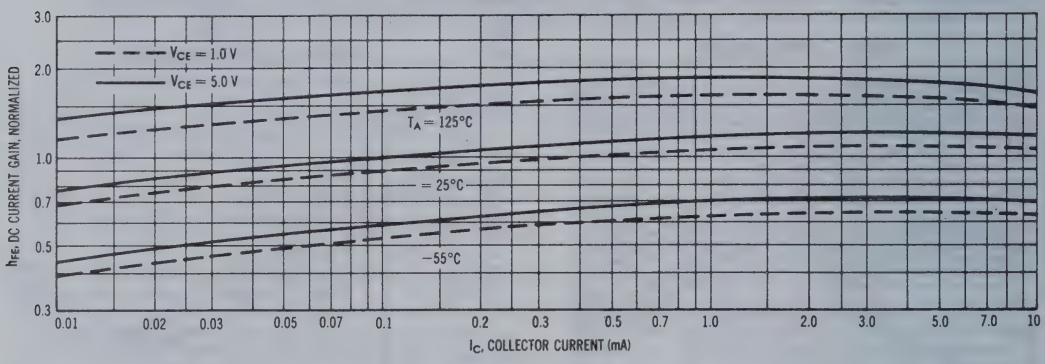


FIGURE 10 — COLLECTOR SATURATION REGION

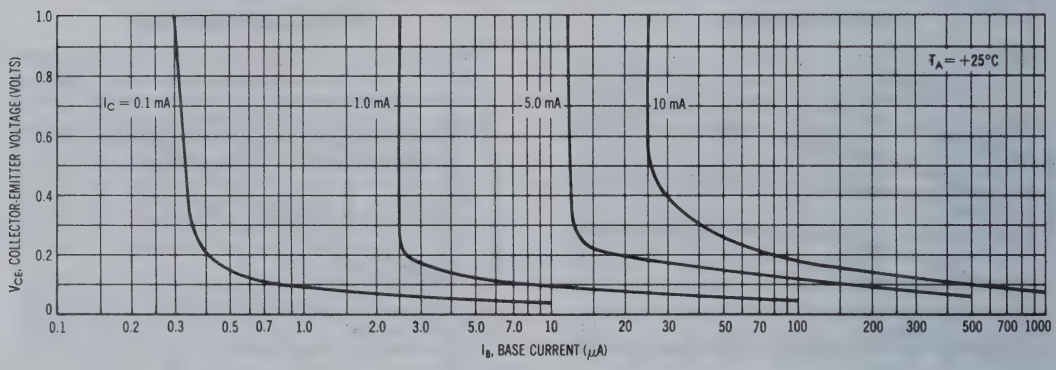


FIGURE 11 — CURRENT GAIN — BANDWIDTH PRODUCT

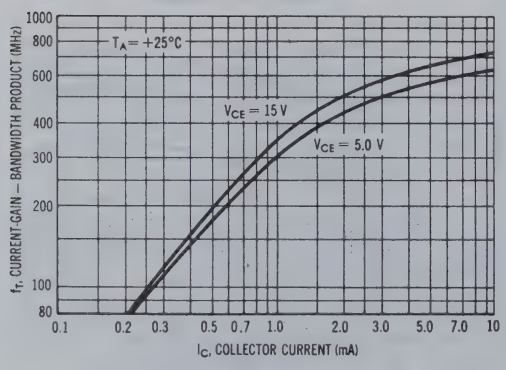
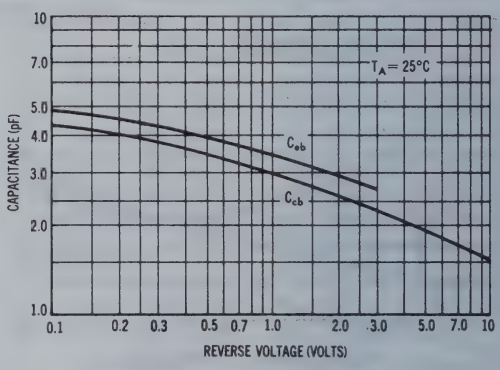


FIGURE 12 — CAPACITANCE



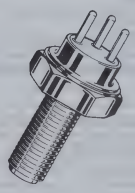
2N5090 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency-multiplier or oscillator circuits in Military or Industrial equipment. Suitable for use as output, driver or pre-driver stages in VHF and UHF equipment.

- 1.2 Watts Output Minimum at 400 MHz (7.8 dB Gain)
- 2.0 Watts Output Typical at 150 MHz (13 dB Gain)
- Multiple-Emitter Overlay Construction for Excellent High-Frequency Performance

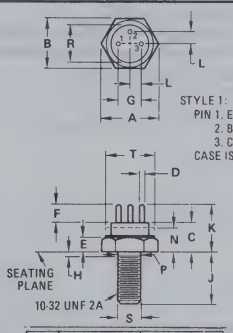
NPN SILICON RF POWER TRANSISTOR



***MAXIMUM RATINGS**

Ratings	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current - Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	5.0 0.04	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.57	13.08	0.495	0.515
B	10.77	11.10	0.424	0.437
C	5.46	8.13	0.215	0.320
D	0.762	1.17	0.030	0.046
E	2.29	3.43	0.090	0.135
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	9.53	11.56	0.375	0.455
K	9.02	12.19	0.355	0.480
L	2.29	2.79	0.090	0.110
N	–	4.19	–	0.165
P	4.14	4.80	0.163	0.189
R	8.13	9.14	0.320	0.360
T	9.14	11.10	0.360	0.437

All JEDEC dimensions and notes apply

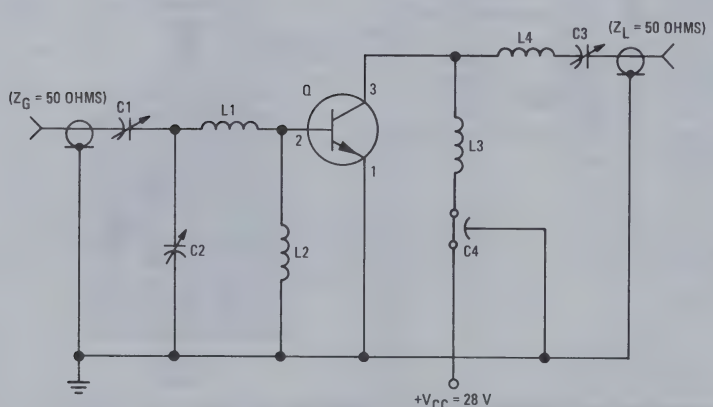
CASE 36
TO-60

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ohms)	$V_{CER(sus)}$	55	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	20	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = -1.5 Vdc) (V_{CE} = 30 Vdc, V_{BE} = -1.5 Vdc, T_C = 200°C)	I_{CEX}	– –	0.1 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	200 –	–
Collector-Emitter Saturation Voltage (I_C = 0.1 Adc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.5	pF
FUNCTIONAL TEST				
Power Input (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	P_{in}	–	0.2	Watt
Collector Efficiency (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	η	45	–	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 400 MHz TEST CIRCUIT



C1 = 0.9–7.0 pF, ARCO 400 or equivalent
C2 = 1.5–20 pF, ARCO 402 or equivalent
C3 = 1.5–20 pF, ARCO 402 or equivalent
C4 = 1000 pF
L1 = 2 turns No. 18 AWG wire, 1/4" ID, 1/8" Long
L2 = RF Choke, 0.1 μH
L3 = 2 turns No. 18 AWG wire, 1/8" ID, 1/8" Long
L4 = 3 turns No. 16 AWG wire, 1/4" ID, 3/8" Long

FIGURE 2 – POWER OUTPUT versus FREQUENCY

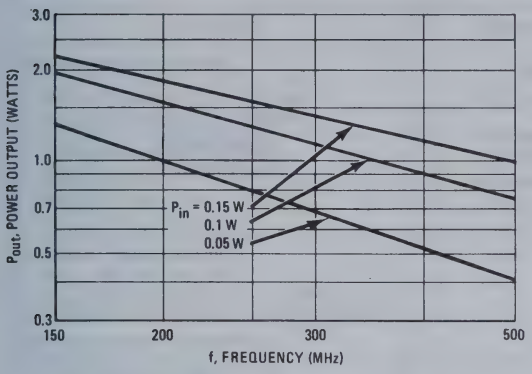


FIGURE 3 – POWER OUTPUT versus POWER INPUT

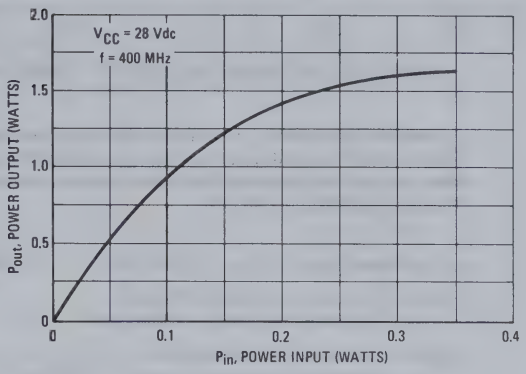


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

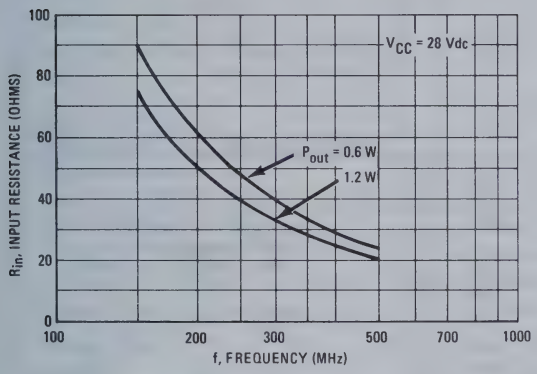


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

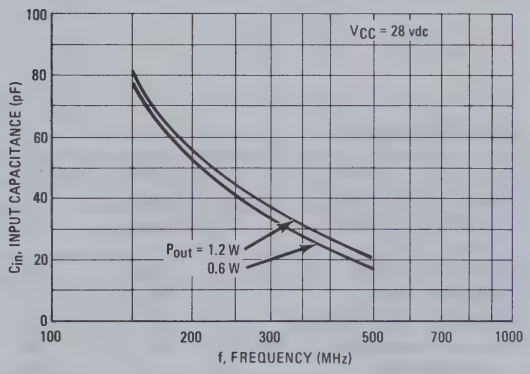
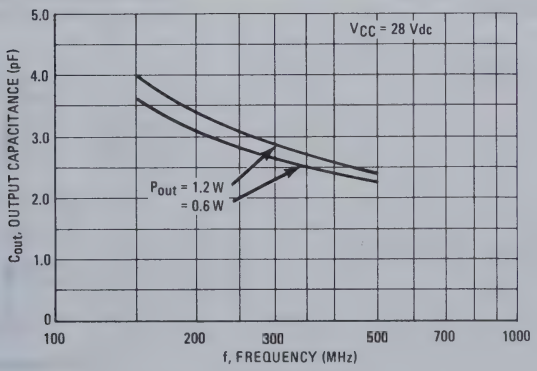


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



2N5108 (SILICON)

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

- High Power Output – P_{out} = 1.0 W (Min) @ f = 1.0 GHz
- High Current-Gain–Bandwidth Product – f_T = 1200 MHz (Min) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications – P_{out} (oscillator) = 300 mW (Typ) @ f = 1.68 GHz

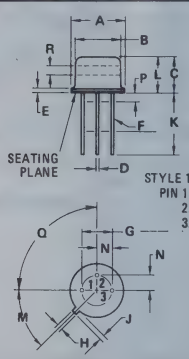
NPN SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
*Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	55	Vdc
*Collector-Base Voltage	V_{CB}	55	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
*Collector Current – Continuous	I_C	0.4	Adc
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts W/°C
*Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

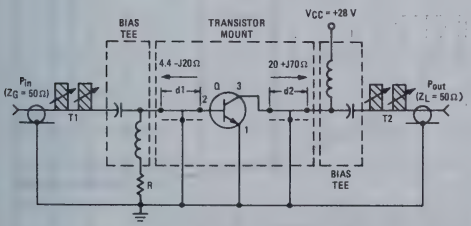
CASE 79-02
Note: All JEDEC notes and dimensions apply.
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	55	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	20	μAdc
*Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 150°C)	I_{CES}	– –	– –	1.0 10	μAdc mAdc
DYNAMIC CHARACTERISTICS					
*Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	–	–	MHz
*Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.3	3.0	pF
FUNCTIONAL TEST					
*Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 28 Vdc, I_C = 102 mAdc, f = 1.0 GHz)	G_{PE}	5.0	–	–	dB
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	1.0	–	–	Watt
*Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	–	–	%
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	–	0.3	–	Watt

*Indicates JEDEC Registered Data.

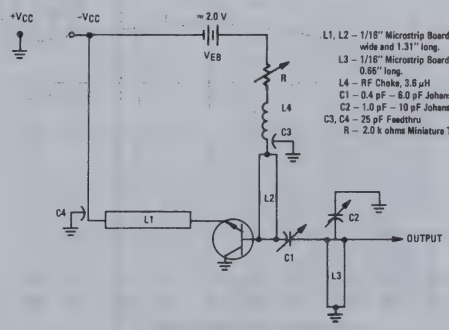
FIGURE 1 – 1 GHz RF AMPLIFIER POWER OUTPUT TEST CIRCUIT



d1: 1" Input line, center conductor width = 0.280"
d2: 1" Output line, center conductor width = 0.125"
Q: 2N5108
R: 3.9 ohms
T1, T2: Microlab Double Stub Tuner, or Equivalent
Bias Tee: Microlab 08N, or Equivalent
Transistor Mount: 1/32" Microstrip board

Note: Impedance measurements are made at transistor socket pins.

FIGURE 2 – 1.68 GHz RF OSCILLATOR POWER OUTPUT TEST CIRCUIT



L1, L2 – 1/16" Microstrip Board. Lines are 0.16" wide and 1.31" long.
L3 – 1/16" Microstrip Board. 0.16" wide and 0.65" long.
L4 – RF Choke, 3.6 μH
C1 – 0.4 pF – 6.0 pF Johanson 4640
C2 – 1.0 pF – 10 pF Johanson 4355
C3, C4 – 25 pF Feedthru
R – 2.0 k ohms Miniature Trim pot

FIGURE 3 – POWER OUTPUT versus POWER INPUT

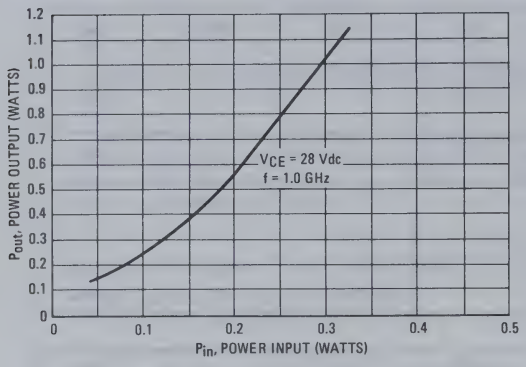


FIGURE 4 – POWER OUTPUT versus FREQUENCY

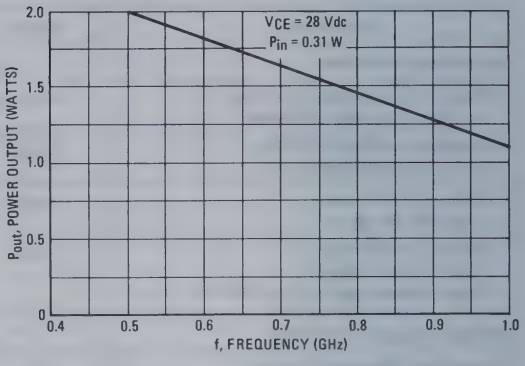


FIGURE 5 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

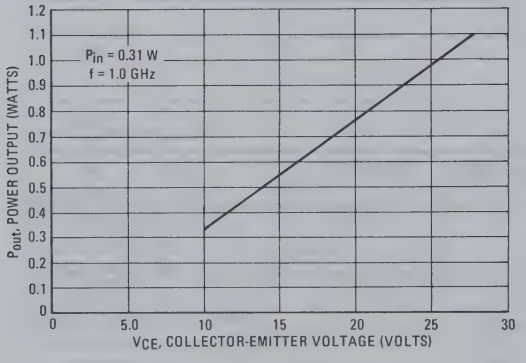


FIGURE 6 – OSCILLATOR POWER OUTPUT versus COLLECTOR CURRENT

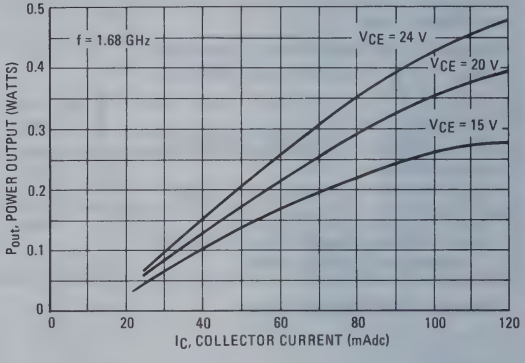


FIGURE 7–CURRENT-GAIN–BANDWIDTH PRODUCT versus CURRENT

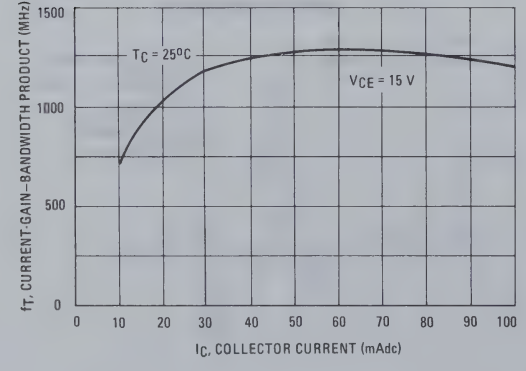
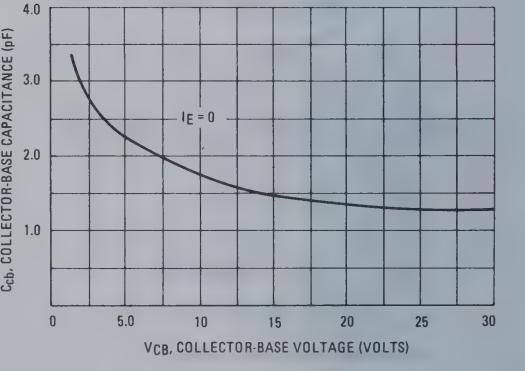


FIGURE 8–COLLECTOR BASE CAPACITANCE versus VOLTAGE



2N5109 (SILICON)

The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed specifically for broadband applications requiring low cross-modulation distortion and low-noise figure. Characterized for use in CATV amplifiers.

- Low Noise Figure – @ f = 200 MHz
  NF = 3.0 dB (Typ)
- High Current-Gain – Bandwidth Product –
  f_T = 1200 MHz (Min) @ I_C = 50 mAdc

WIDE BAND AMPLIFIER

NPN SILICON
HIGH-FREQUENCY
TRANSISTOR

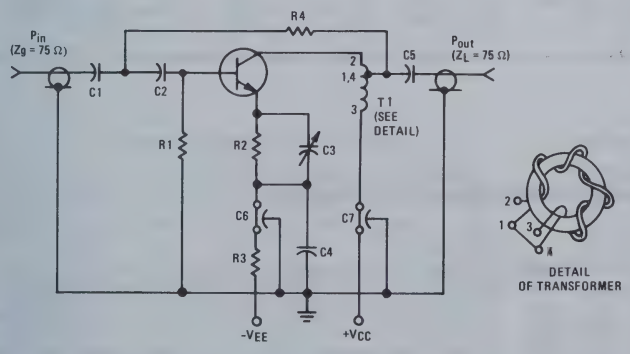


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Base Current – Continuous	I_B	400	mAdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 75°C (1) Derate above 25°C	P_D	2.5 20	Watt mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

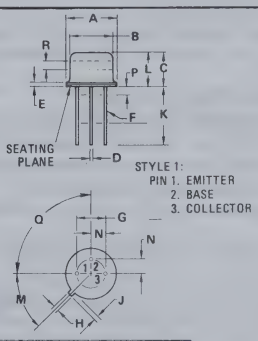
(1) Total Device Dissipation at T_A = 25°C is 1.0 Watt.
* Indicates JEDEC Registered Data.

FIGURE 1 – VOLTAGE GAIN TEST CIRCUIT



DETAIL
OF TRANSFORMER

C1, C2, C5 0.002 μF
C3 8 – 60 pF, ARCO 404 or Equivalent
C4 0.03 μF
C6, C7 1,500 pF
R1 390 OHMS, 1/2 WATT
R2 6.8 OHMS, 1/2 WATT
R3 330 OHMS, 1 WATT
R4 270 OHMS, 1/2 WATT
T1 4 turns, Bifilar winding, 3/16" I.D., #30 AWG
CORE MATERIAL: Indiana General CF-102-Q1



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

Note: All JEDEC notes and dimensions apply.

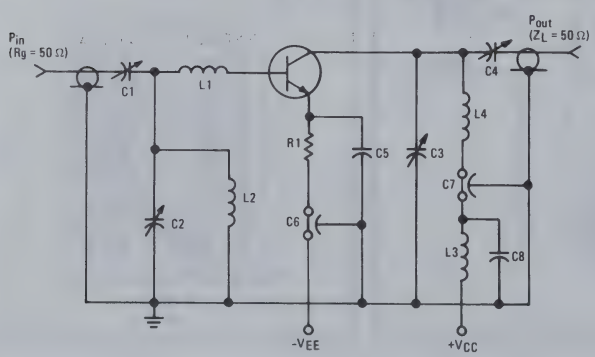
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	V_{CEO} (sus)	20	–	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	V_{CER} (sus)	40	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	20	μAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = -1.5 V, T_C = 150°C) (V_{CE} = 35 Vdc, V_{BE} = -1.5 V)	I_{CEX}	– –	– –	5.0 5.0	mAdc mAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
***ON CHARACTERISTICS**					
DC Current Gain (I_C = 360 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	 5.0 40	 – –	 – 120	 – –
DYNAMIC CHARACTERISTICS					
*Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	–	–	MHz
*Collector-Base Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.8	3.5	pF
Noise Figure (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 2)	NF	–	3.0	–	dB
FUNCTIONAL TEST					
*Common-Emitter Amplifier Voltage Gain (Figure 1) (I_C = 50 mAdc, V_{CC} = 15 Vdc, f = 50 to 216 MHz)	G_{ve}	11	–	–	dB
Cross-Modulation Distortion (Figure 3) (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = 54 dBmV)	XM	–	-70	–	dB
*Power Input (Figure 2) (I_C = 50 mAdc, V_{CC} = 15 Vdc, R_S = 50 ohms, P_{out} = 1.26 mW, f = 200 MHz)	P_{in}	–	–	0.1	mW

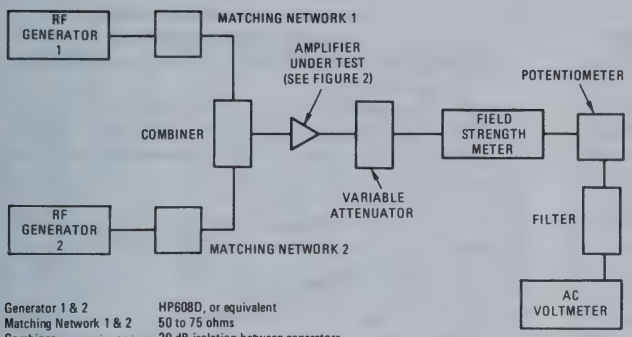
*Indicates JEDEC Registered Data.
(1) Pulsed thru a 25 mH Inductor; 50% Duty Cycle

FIGURE 2 — 200 MHz POWER GAIN TEST CIRCUIT



C1, C2, C3 1.0 – 30 pF
C4 1.0 – 20 pF
C5 10,000 pF
C6, C7 1,000 pF
C8 0.01 μF
L1 4-1/2 turns, No. 22 wire, 3/16" I.D.
L4 3-1/2 turns, No. 22 wire, 3/16" I.D.
L2, L3 0.82 μH RFC
R1 240 OHMS, 2 WATTS

FIGURE 3 – CROSS MODULATION TEST SETUP



Generator 1 & 2	HP608D, or equivalent
Matching Network 1 & 2	50 to 75 ohms
Combiner	20 dB isolation between generators
Variable Attenuator	As required
Field Strength Meter, with Detector Output	50 – 220 MHz
Filter	1000 Hz
AC Voltmeter	Ballantine 861, or equivalent

OPERATING INSTRUCTIONS FOR CROSS MODULATION TEST

1. Set up equipment as shown in Fig. 3
2. Set generator 1 to 150 MHz modulated 30% by 1,000 hertz, and tune field strength meter to 150 MHz.
3. Adjust output level of generator 1 to give rated output from the amplifier under test.
4. Adjust potentiometer and AC voltmeter for a convenient level. This level then corresponds to 100% cross modulation.
5. Remove modulation. Readjust output level of generator 1 if necessary to obtain the AC voltmeter "100% level". Do not readjust generator 1 during the following steps.
6. Set generator 2 to 210 MHz modulated 30% by 1,000 hertz and tune field strength meter to 210 MHz.
7. Adjust output level of generator 2 to give rated output of the amplifier, i.e. The AC voltmeter indicates the "100% level".
8. Tune field strength meter to 150 MHz CW and read the AC voltmeter (a change of the AC voltmeter scale may be necessary).
9. Calculate percentage of cross modulation by comparing the reading of step 8 to the "100% level".

FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

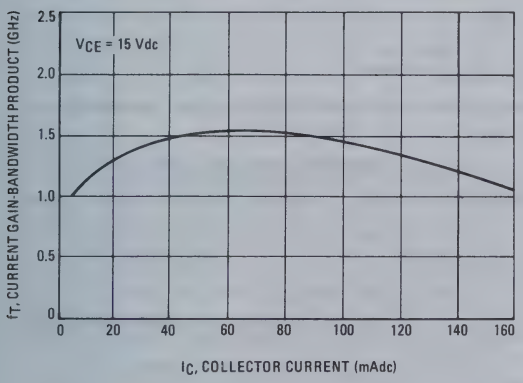


FIGURE 5 – COLLECTOR-BASE TIME CONSTANT

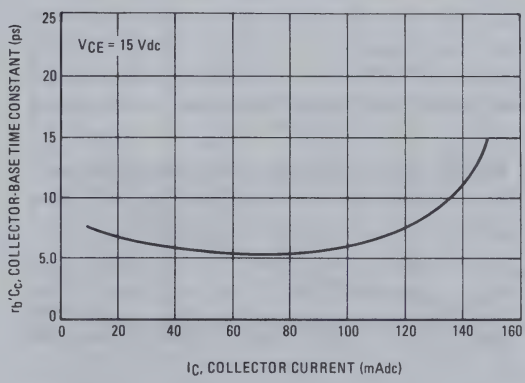


FIGURE 6 – SATURATION VOLTAGES

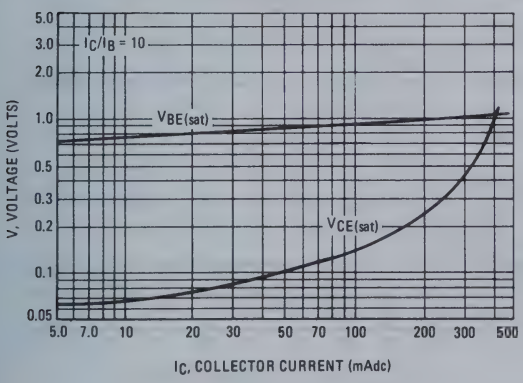


FIGURE 7 – CAPACITANCES versus REVERSE VOLTAGE

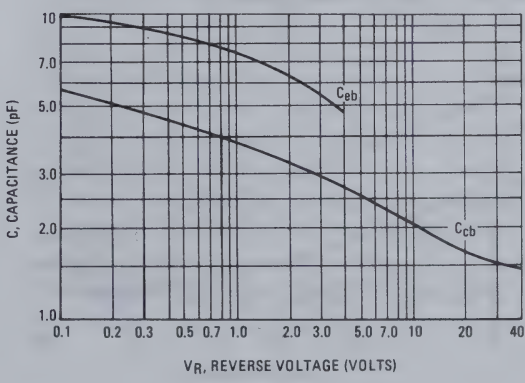


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

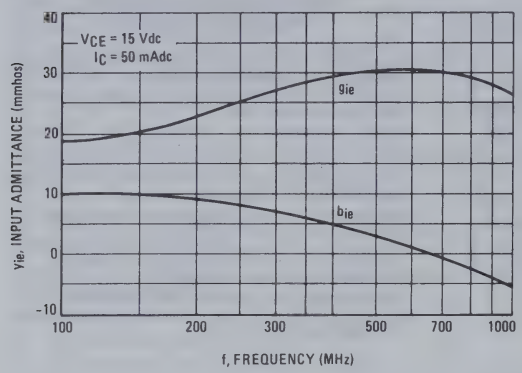


FIGURE 9 – INPUT ADMITTANCE versus COLLECTOR CURRENT

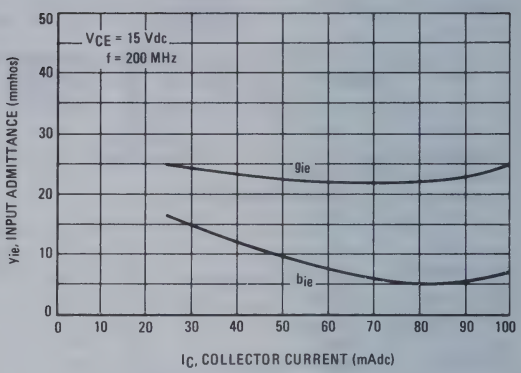


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

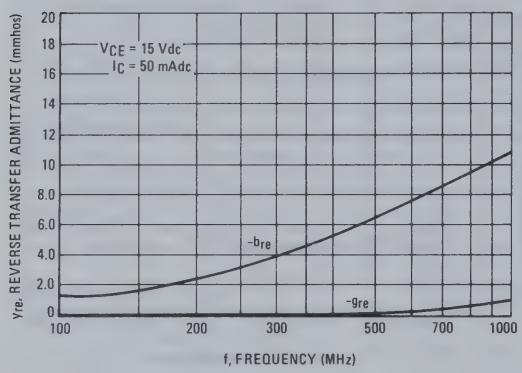


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

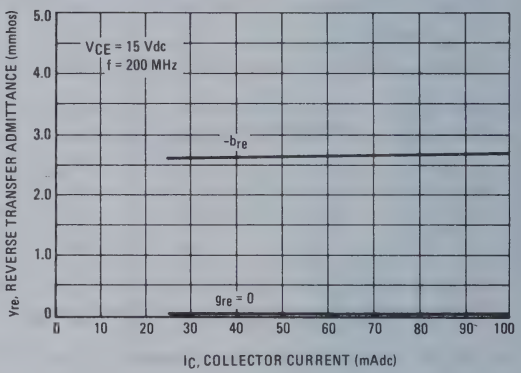


FIGURE 12 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

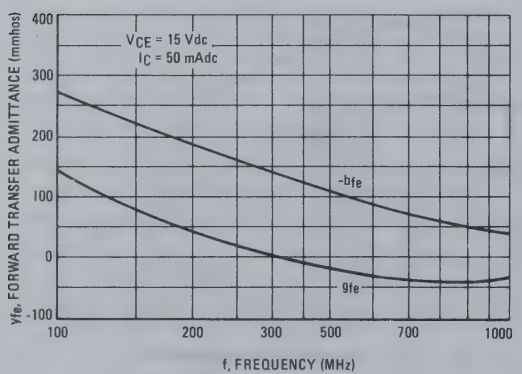


FIGURE 13 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

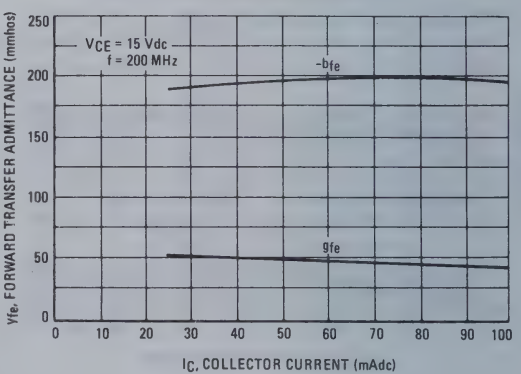


FIGURE 14 – OUTPUT ADMITTANCE versus FREQUENCY

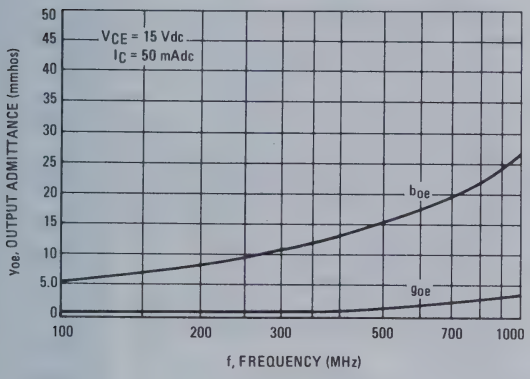


FIGURE 15 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

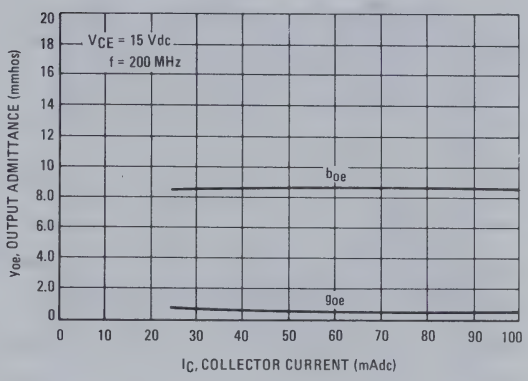


FIGURE 16 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

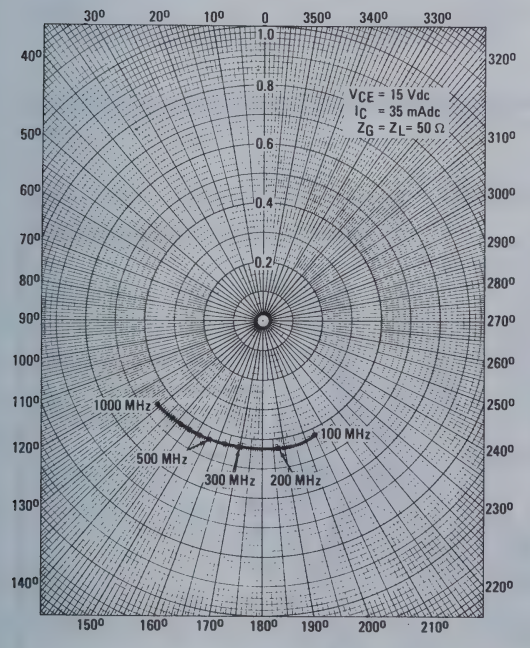


FIGURE 17 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

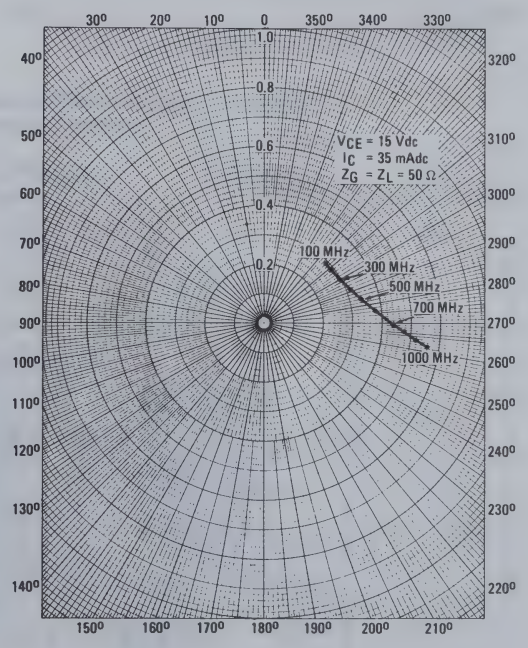


FIGURE 18 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

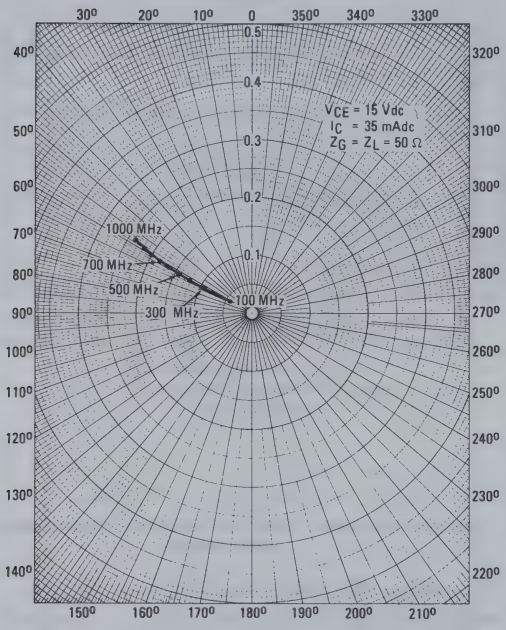


FIGURE 19 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

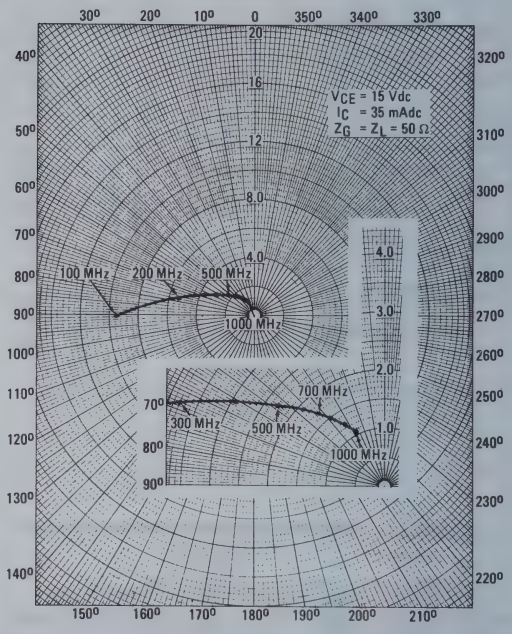
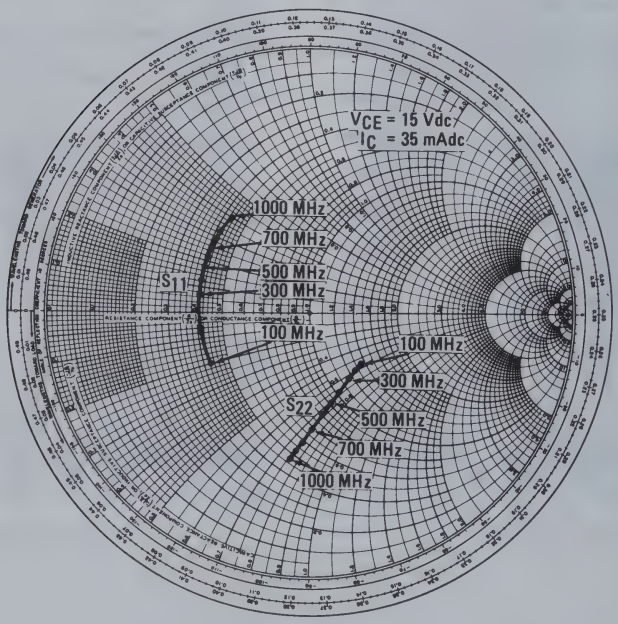
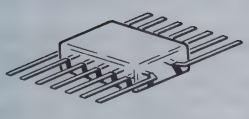


FIGURE 20 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

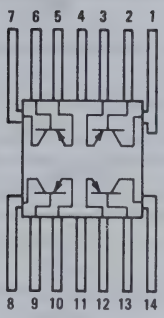


2N5146 (SILICON)

Quad PNP silicon annular transistor designed for medium-current, high-speed switching and driver applications.



CASE 607-04
(TO-86)



Lead 1 identified by color dot or by elbow on lead. All leads electrically isolated from package.

MAXIMUM RATINGS (each device)

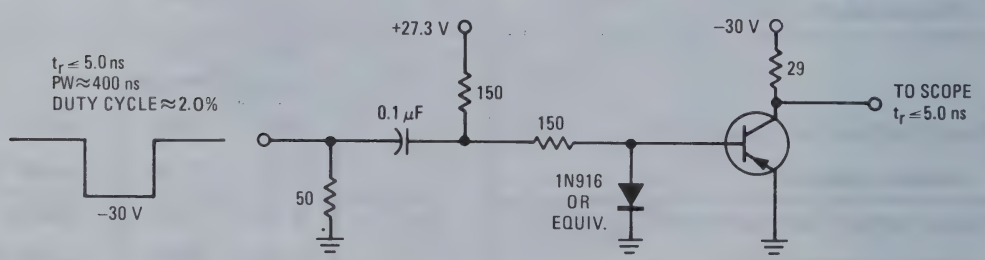
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D	400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.25	5.0	Watts
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	I_{CEX}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	I_{BL}	-	-	200	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	40	-	-
Collector-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	-	0.7	1.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	-	1.1	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)	t_s	-	30	80	ns
Fall Time		t_f	-	16	30	ns

(1) Pulse test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2N5155 (GERMANIUM)

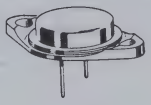
PNP GERMANIUM POWER TRANSISTORS

. . . designed for high-current switching applications requiring low saturation voltages, fast switching times and above average Collector-Emitter Sustaining capability.

- Alloy Diffused Epitaxial Construction
- Low Saturation Voltages —
  $V_{CE(sat)}$ = 0.9 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.4 Vdc (Max) @ I_C = 25 Adc
- DC Current Gain —
  h_{FE} = 25 (Min) @ I_C = 8.0 Adc

25 AMPERE
PNP ADE GERMANIUM POWER TRANSISTOR

140 VOLTS
106 WATTS



*MAXIMUM RATINGS

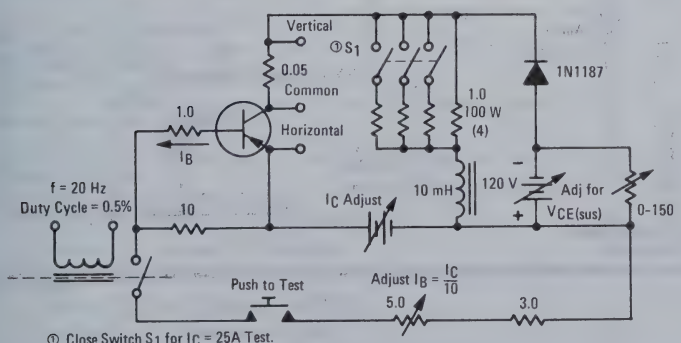
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	1.5	Vdc
Collector Current - Continuous ** - Continuous - Peak	I_C	15 25 25	Adc
Base Current - Continuous	I_B	5.0	Adc
**Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

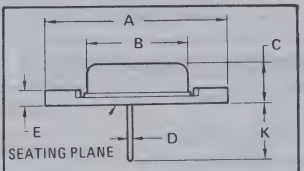
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

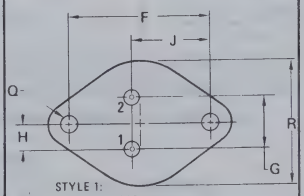
*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to the JEDEC Registered data shown.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



① Close Switch S_1 for I_C = 25A Test.





STYLE 1:
PIN 1. BASE
2. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case
CASE 11A

2N5155 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	120	-	Vdc
*Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 8.0 Adc, R_{EB} = 10 Ohms)	$V_{CEO(sus)}$	120	-	Vdc
(I_C = 25 Adc, R_{EB} = 10 Ohms)		80	-	
*Collector Cutoff Current (V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	I_{CEX}	-	10	mAdc
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)		-	25	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
*Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	-	500	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
*Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{CE(sat)}$	-	0.9	Vdc
*Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{BE(sat)}$	-	1.4	Vdc
Pulse Energy Test (Note 1) (See Figure 2) (I_C = 4.2 Adc, V_{CE} = 30 Vdc)	PET	1.26	-	Joule
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, f = 50 kHz)	f_T	100	-	kHz
SWITCHING CHARACTERISTICS				
Rise Time	(V_{CC} = -12 Vdc, I_C = 10 Adc,	t_r	-	18	μs
Storage Time	I_{B1} = 1.0 Adc, I_{B2} = 1.0 Adc)	t_s	-	12	μs
Fall Time	(See Figure 3)	t_f	-	18	μs

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 10 ms, Duty Cycle = 2.5%.

FIGURE 2 – PULSE ENERGY TEST CIRCUIT

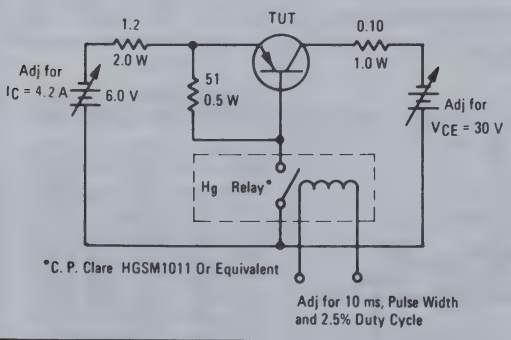
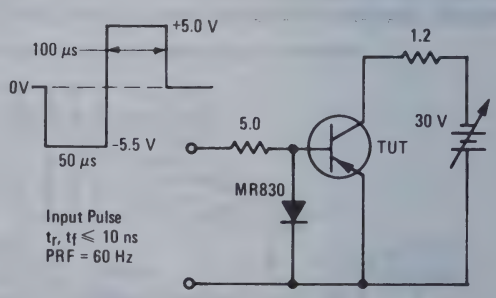


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



2N5157 (SILICON)

For Specifications, See 2N3902, Volume I.

2N5160 (SILICON)



CASE 79
(TO-39)

Collector connected to case

PNP silicon RF power transistors designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C output driver, or pre-driver stages in VHF and UHF.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	-	-	20	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	-	-	0.1	mAdc
Collector Cutoff Current (V_{CB} = 28 Vdc, I_E = 0)	I_{CBO}	-	-	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	900	-	MHz
Collector-Base Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	-	2.5	4.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	G_{PE}	8.0 -	8.8 14.5	- -	dB
Power Output (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	P_{out}	1.0 -	1.2 1.4	- -	Watt
Collector Efficiency (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz)	η	45	55	-	%

FIGURE 1 – 400-MHz TEST CIRCUIT

C_1 – 10 pF
C_2, C_3, C_4, C_5 – 1.0 – 10 pF variable
C_6 – 2400 pF feed through
C_7 – 0.004 μF
C_8 – 0.01 μF
L_1 – 30 nH, 1 turn, No. 20 AWG
L_2 – 75 nH, 3 turns, No. 20 AWG
L_3 – 0.33 μH, R.F.C.

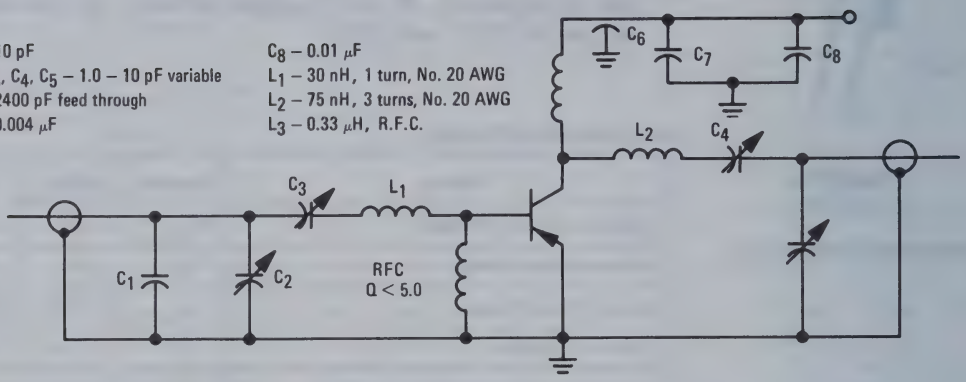


FIGURE 2 – POWER OUTPUT versus FREQUENCY

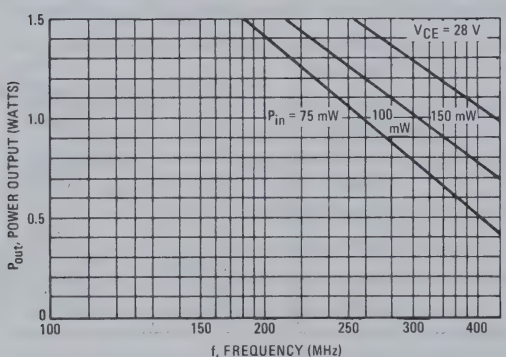


FIGURE 3 – POWER OUTPUT versus POWER INPUT

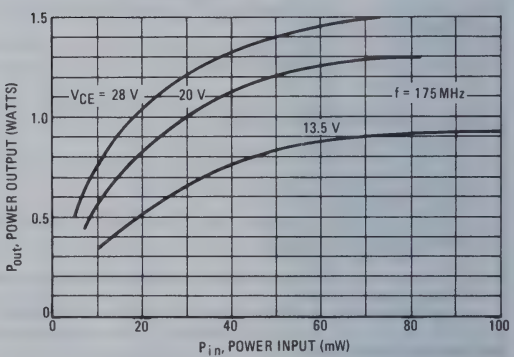


FIGURE 4 – PARALLEL INPUT IMPEDANCE versus FREQUENCY

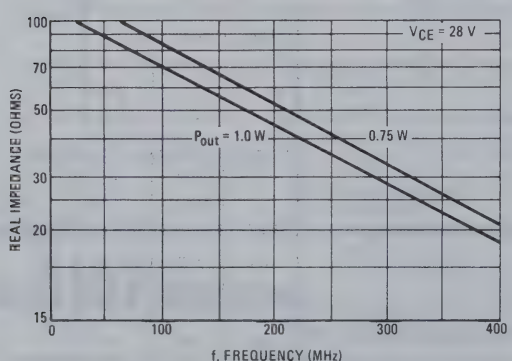


FIGURE 5 – PARALLEL INPUT IMPEDANCE versus FREQUENCY

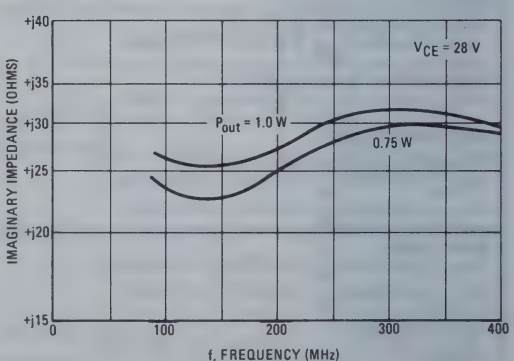


FIGURE 6 – PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

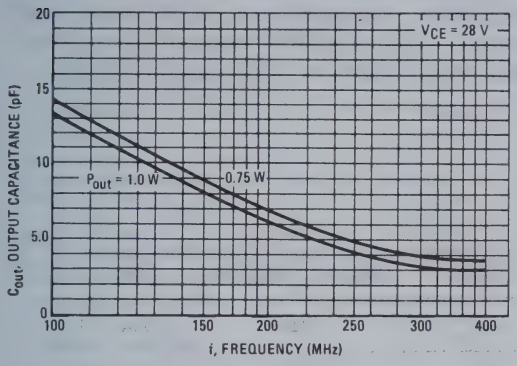


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT

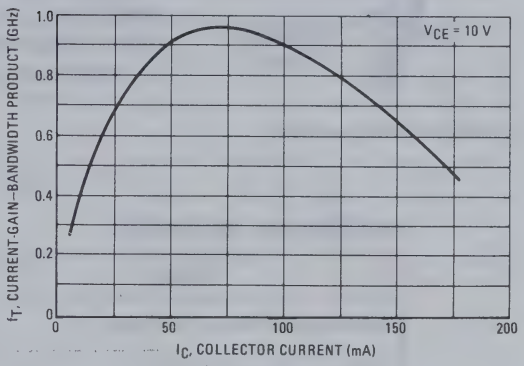


FIGURE 8 – 2N5160 300-MHz COMPLEMENTARY POWER OUTPUT CIRCUIT

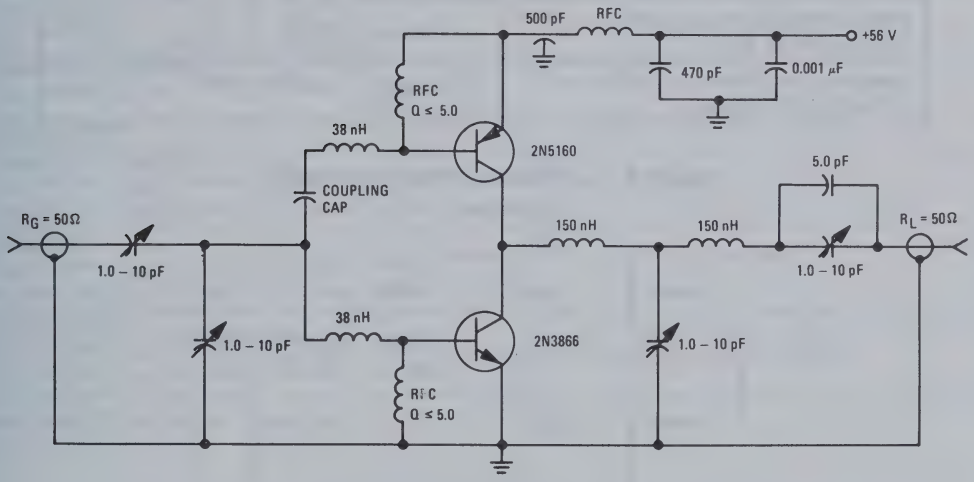
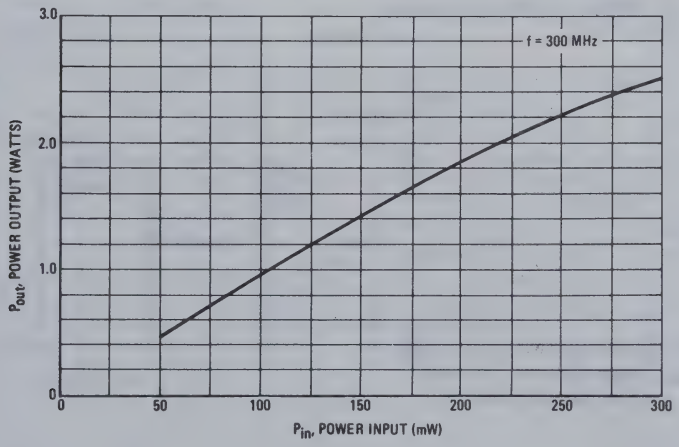


FIGURE 9 – COMPLEMENTARY CIRCUIT – POWER OUTPUT versus POWER INPUT



2N5161 (SILICON)
2N5162



CASE 36
(TO-60)

Case common to emitter

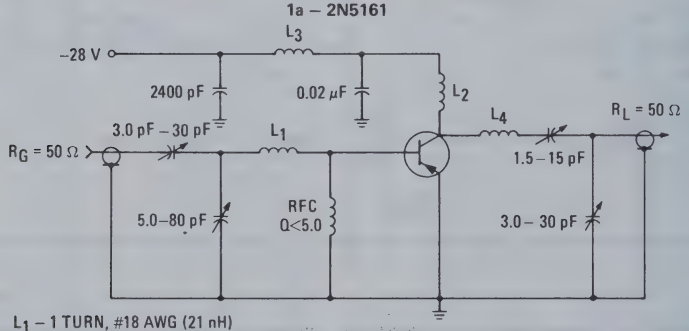
PNP silicon RF power transistors designed for amplifier or oscillator applications in military and industrial equipment. Suitable for use as Class B or C output or power oscillator in VHF applications.

MAXIMUM RATINGS

Rating	Symbol	2N5161	2N5162	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current	I_C	1.5	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.114	50 0.286	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

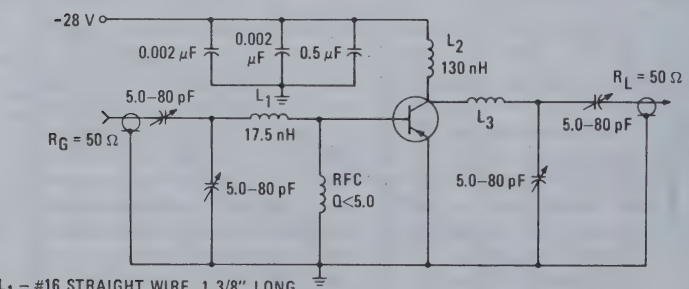
FIGURE 1 – 175 MHz TEST CIRCUITS

1a – 2N5161



L_1 – 1 TURN, #18 AWG (21 nH)
L_2, L_3 – 0.33 μH RFC
L_4 – 4 TURNS, #16 AWG, ½" I.D. (200 nH)

1b – 2N5162



L_1 – #16 STRAIGHT WIRE, 1 3/8" LONG.
L_2 – 5 TURNS #20 AWG, 1/2" LONG.
L_3 – 1 TURN #18 AWG WIRE.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)		$V_{CEO(sus)}$*	40	-	-	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N5161		4.0	-	-	
(I_E = 5.0 mAdc, I_C = 0)	2N5162		4.0	-	-	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)	2N5161		-	-	0.5	
	2N5162		-	-	1.0	
(V_{CE} = 28 Vdc, V_{BE} = 0, T_C = 200°C)	2N5161		-	-	5.0	
	2N5162		-	-	10	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 28 Vdc, I_E = 0)	2N5161		-	-	0.1	
	2N5162		-	-	0.2	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	2N5161		10	-	-	
(I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	2N5162		10	-	-	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 200 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N5161		-	500	-	
(I_C = 500 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N5162		-	500	-	
Collector-Base Capacitance		C_{cb}				pF
(V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5161		-	10	15	
	2N5162		-	45	60	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(V_{CC} = 28 Vdc, P_{out} = 7.5 Watts, f = 175 MHz)	2N5161		8.75	10.3	-	
(V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 175 MHz)	2N5162		6.0	7.0	-	
Power Output		P_{out}				Watts
(V_{CC} = 28 Vdc, P_{in} = 1.0 Watt, f = 175 MHz)	2N5161		7.5	8.5	-	
(V_{CC} = 28 Vdc, P_{in} = 7.5 Watts, f = 175 MHz)	2N5162		30	35	-	
Collector Efficiency		η				%
(V_{CC} = 28 Vdc, P_{out} = 7.5 Watts, f = 175 MHz)	2N5161		45	-	-	
(V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 175 MHz)	2N5162		55	-	-	

* Pulsed through 25 mH inductor

2N5161 DESIGN DATA

FIGURE 2 – POWER OUTPUT versus FREQUENCY

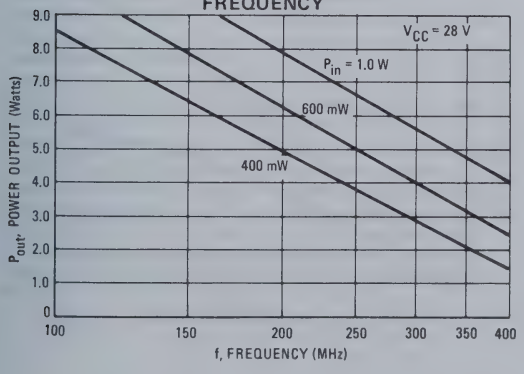
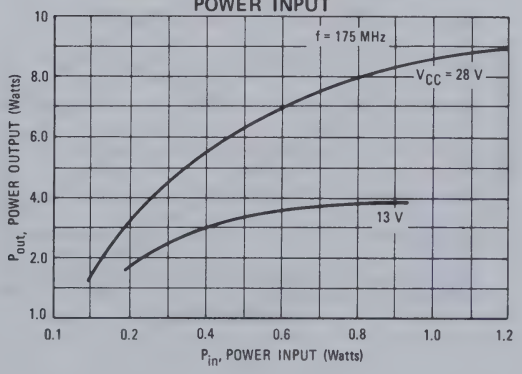


FIGURE 3 – POWER OUTPUT versus POWER INPUT



LARGE SIGNAL IMPEDANCE DATA

FIGURE 4 – REAL SERIES INPUT RESISTANCE versus FREQUENCY

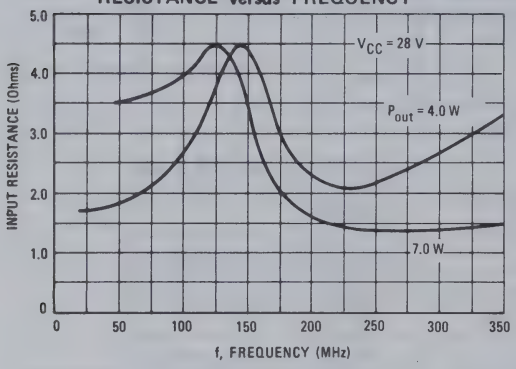


FIGURE 5 – IMAGINARY SERIES INPUT REACTANCE versus FREQUENCY

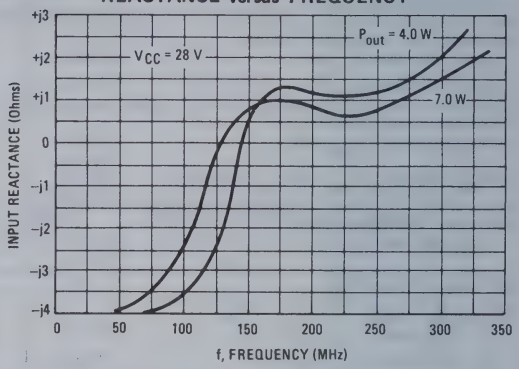
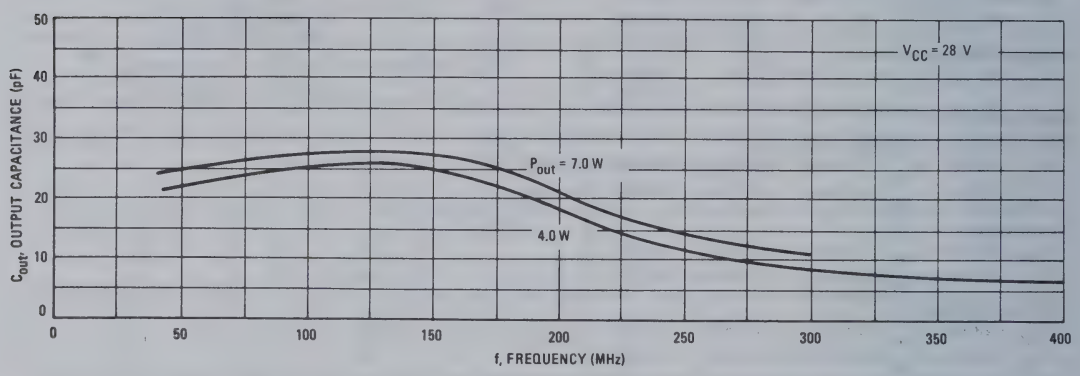


FIGURE 6 – OUTPUT CAPACITANCE versus FREQUENCY



2N5162 DESIGN DATA

FIGURE 7 – POWER OUTPUT versus FREQUENCY

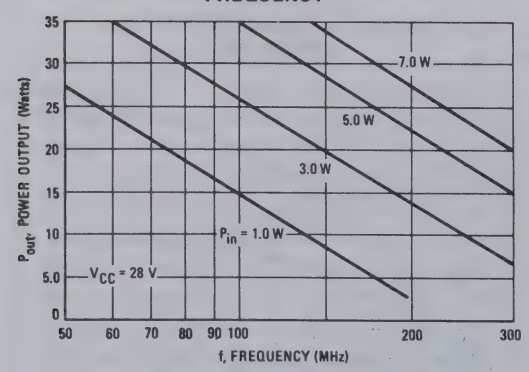
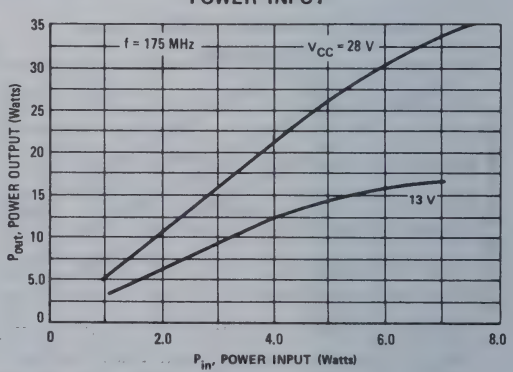


FIGURE 8 – POWER OUTPUT versus POWER INPUT



LARGE SIGNAL IMPEDANCE DATA

FIGURE 9 – REAL SERIES INPUT RESISTANCE versus FREQUENCY

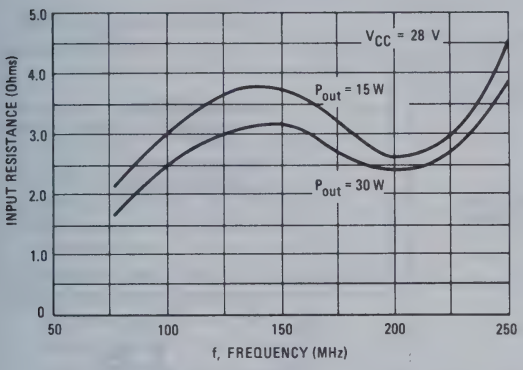


FIGURE 10 – IMAGINARY SERIES INPUT REACTANCE versus FREQUENCY

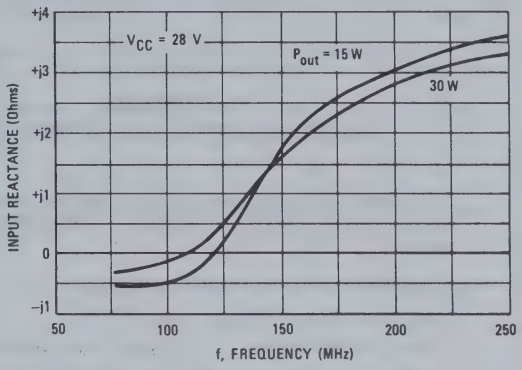
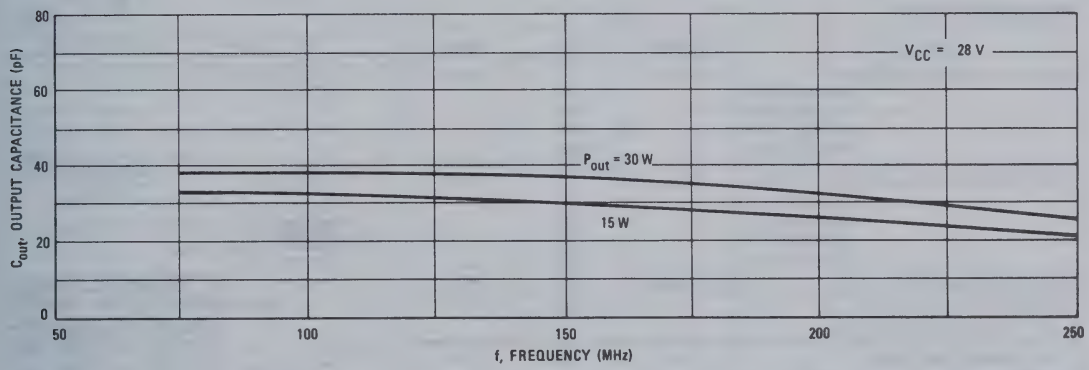


FIGURE 11 – OUTPUT CAPACITANCE versus FREQUENCY



2N5164 thru 2N5171 (SILICON)
2N5164R thru 2N5171R

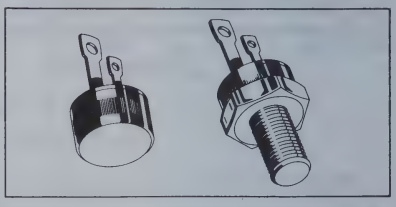
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Supplied in Either Pressfit or Stud Package
- High Surge Current Rating – I_{TSM} = 240 Amp
- Low On-State Voltage – 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics – 10 mA (Typ) @ T_C = 25°C

THYRISTORS
PNPN

50–600 VOLTS
20 AMPERES RMS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1) 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RRM}	 50 200 400 600	Volts
*Non-repetitive Peak Reverse Blocking Voltage 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RSM}	 75 300 500 700	Volts
Forward Current RMS	$I_{T(RMS)}$	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≤ 8.3 ms)	I^2t	235	A^2s
*Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	240	Amp
*Peak Forward Gate Power	P_{GFM}	5.0	Watts
*Average Forward Gate Power	$P_{GF(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GFM}	2.0	Amp
Peak Gate Voltage – Forward (2) Reverse	V_{GFM} V_{GRM}	10 10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (3) 2N5168-2N5171		30	in. lb.

THERMAL CHARACTERISTICS

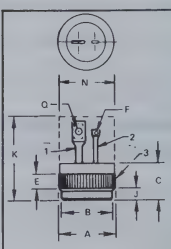
Characteristic	Symbol	Typ	Max	Unit
*Thermal Resistance, Junction to Case 2N5164,65,66,67 2N5168,69,70,71	θ_{JC}	 1.0 1.1	 1.5 1.6	°C/W

*Indicates JEDEC Registered Data.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.

(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or glass seal broken.

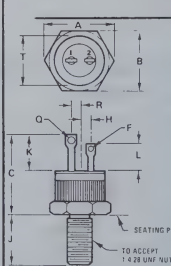


All JEDEC dimensions and notes apply

CASE 174-02
TO-203AA

STYLE 1:
TERM. 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.726	12.827	0.501	0.505
B	11.811	12.065	0.465	0.475
C	8.39	9.65	0.330	0.380
E	2.54	–	0.100	–
F	0.89	1.72	0.035	0.068
J	2.04	2.46	0.080	0.097
K	–	20.32	–	0.800
N	–	12.95	–	0.510
Q	1.66	2.28	0.065	0.090



CASE 175

STYLE 1:
TERM. 1. CATHODE
2. GATE
STUD : ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.34	15.60	0.604	0.614
B	14.00	14.20	0.551	0.559
C	20.70	24.13	0.815	0.950
F	1.40	1.65	0.055	0.065
H	2.29 REF		0.090 REF	
J	10.67	11.56	0.420	0.455
K	9.78	10.54	0.385	0.415
L	6.99	7.75	0.275	0.305
Q	2.03	2.41	0.080	0.095
R	1.65 REF		0.065 REF	
T	12.70	12.83	0.500	0.505

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
*Peak Forward Blocking Voltage (T_J = 100°C)	2N5164, 2N5168	V_{DRM}(1)	50	–	Volts
	2N5165, 2N5169		200	–	
	2N5166, 2N5170		400	–	
	2N5167, 2N5171		600	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)		I_{DRM}	–	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 100°C, gate open)		I_{RRM}	–	5.0	mA
Gate Trigger Current (Continuous dc)		I_{GT}(2)			mA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)			–	40	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)			–	75	
Gate Trigger Voltage (Continuous dc)		V_{GT}			Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)			–	1.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)			–	2.5	
*(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)		V_{GD}	0.2	–	
Forward "ON" Voltage (pulsed, 1.0 ms max, duty cycle ≤1%)		V_{TM}			Volts
(I_{TM} = 20 A)			–	1.5	
(I_{TM} = 41 A)			–	1.7	
Holding Current		I_H			mA
(Anode Voltage = 7.0 Vdc, gate open)			–	50	
*(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)			–	90	
Turn-On Time (t_d + t_r) (I_{TM} = 20 A, I_{GT} = 40 mAdc)		t_{on}	TYPICAL 1.0		μs
Turn-Off Time		t_{off}			μs
(I_{TM} = 10 A, I_R = 10 A)			20		
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C) (V_{DRM} = rated voltage) (dv/dt = 30 V/μs)			30		
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	50		V/μs

*Indicates JEDEC Registered Data.

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA.

EFFECT OF TEMPERATURE UPON TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – GATE TRIGGER CURRENT

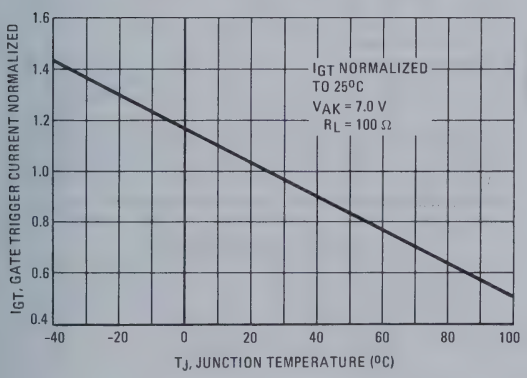
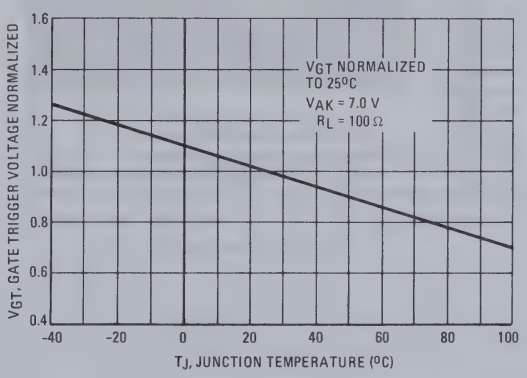


FIGURE 2 – GATE TRIGGER VOLTAGE



MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT

FIGURE 3 – 60 Hz SURGES

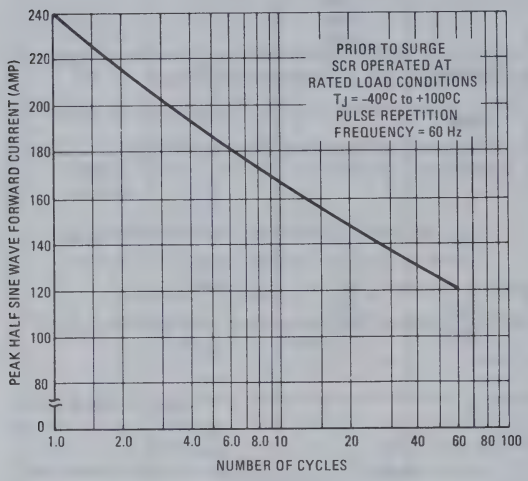


FIGURE 4 – SUB-CYCLE SURGES

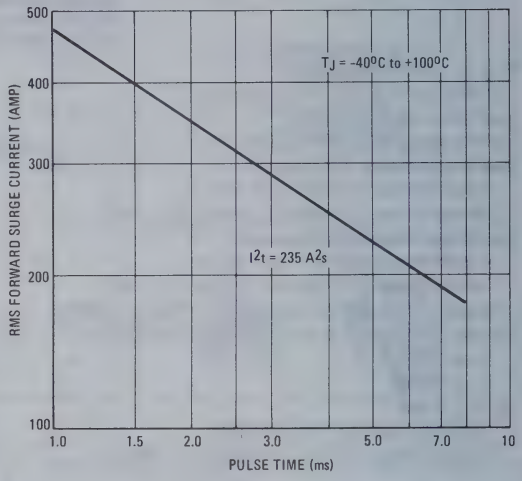


FIGURE 5 – GATE TRIGGER CHARACTERISTICS

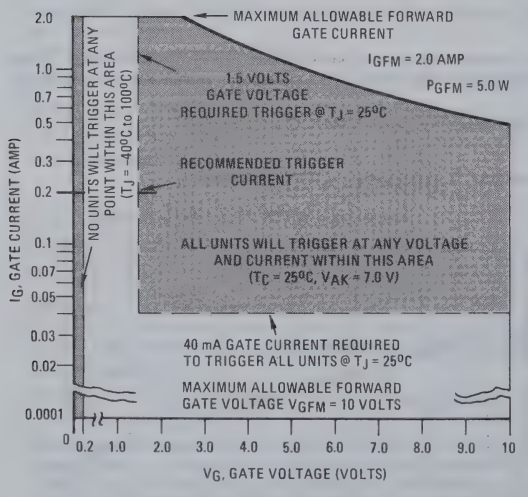
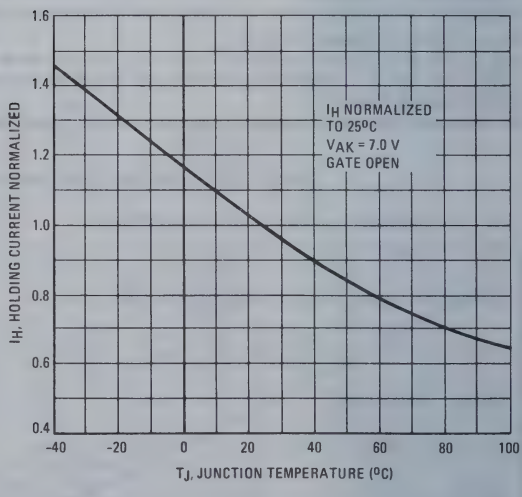


FIGURE 6 – EFFECT OF TEMPERATURE ON TYPICAL HOLDING CURRENT



DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 60 to 400 Hz, SINE WAVE)

FIGURE 7 – CURRENT DERATING(1)

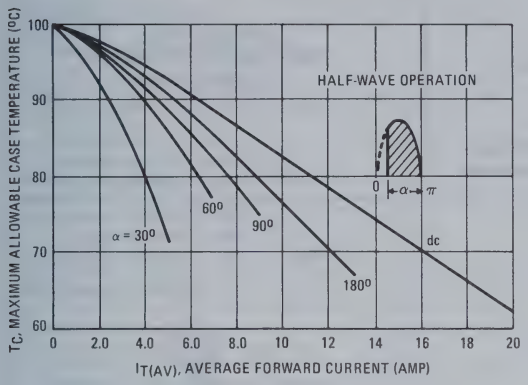


FIGURE 8 – FORWARD POWER DISSIPATION

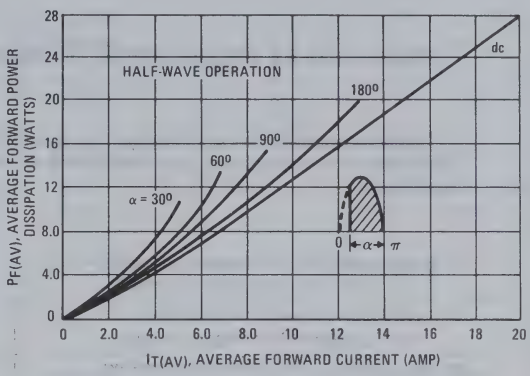


FIGURE 9 – FORWARD CONDUCTION CHARACTERISTICS

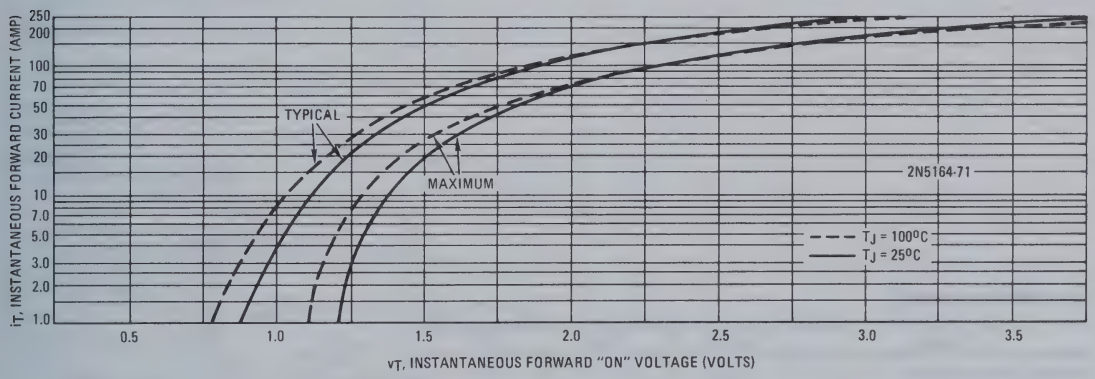
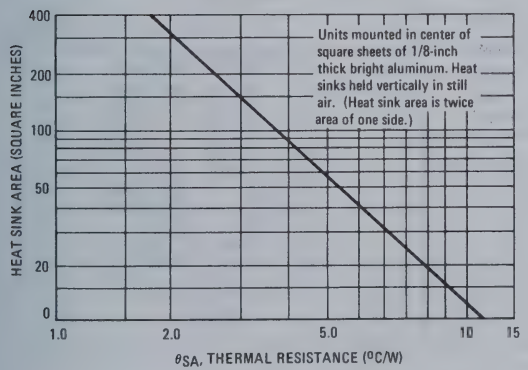


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES



(1) Reverse polarity units must be derated an additional 10%; i.e., in Figure 7 the maximum allowable case temperature of the 2N5164 at 16 Adc is 70°C, a derating of 30°C below the maximum junction temperature. For the 2N5164R the derating would be an additional 10% or 3.0°C, making the allowable case temperature 67°C.

For additional mounting information, refer to the Motorola brochure "Mounting Techniques for Pressfit Silicon Rectifiers and Silicon Controlled Rectifiers".

2N5179 (SILICON)

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain — Bandwidth Product —
  f_T = 1.4 GHz (Typ) @ I_C = 10 mAdc
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 14 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Low Noise Figure —
  NF = 4.5 dB (Max) @ f = 200 MHz

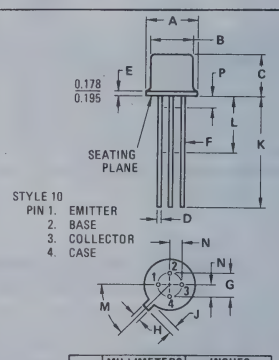
NPN SILICON RF SMALL-SIGNAL TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 20 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	2.5	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b C_c$	3.0	14	ps
Noise Figure (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	–	4.5	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	–	dB
Power Output (See Figure 2) (V_{CB} = 10 Vdc, I_E = 12 mAdc, f≥500 MHz)	P_{out}	20	–	mW

*Indicates JEDEC Registered Values.

①f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT

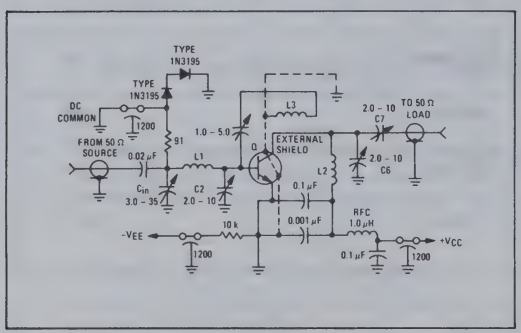


FIGURE 2 – 500 MHz OSCILLATOR CIRCUIT

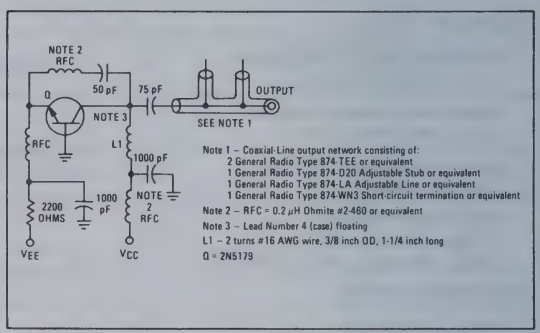


FIGURE 3 – NOISE FIGURE versus FREQUENCY

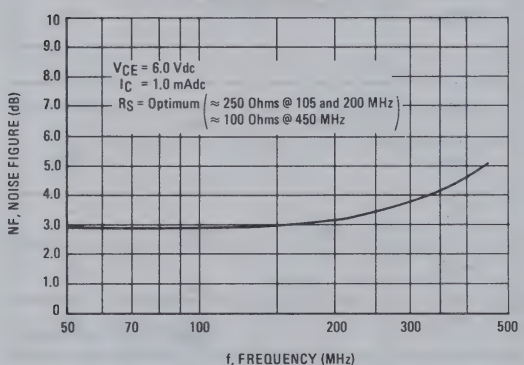


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

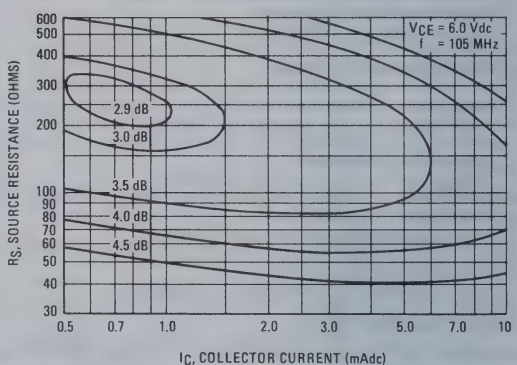


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

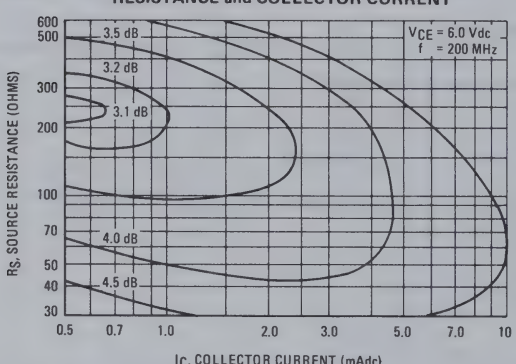


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

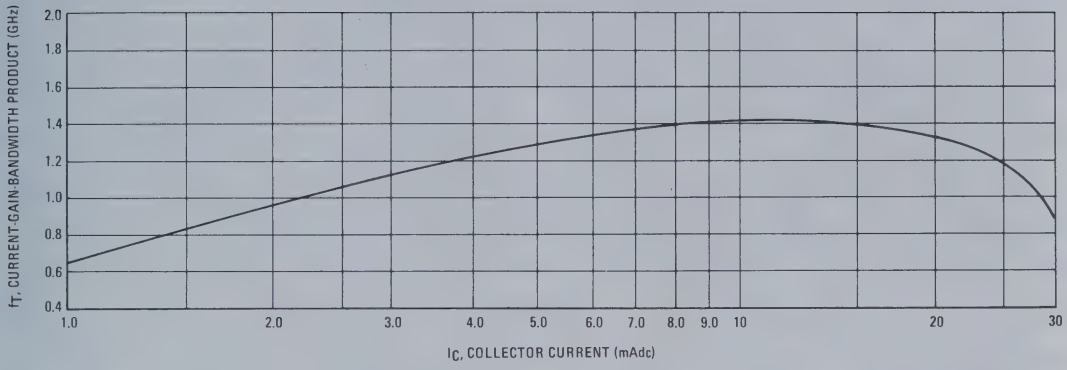


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

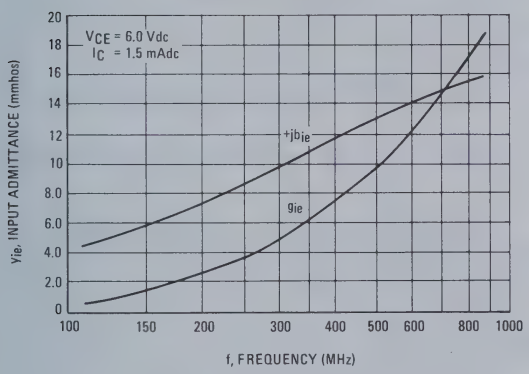


FIGURE 8 – OUTPUT ADMITTANCE versus FREQUENCY

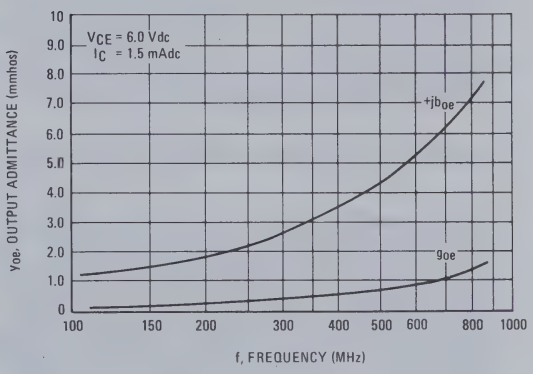


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

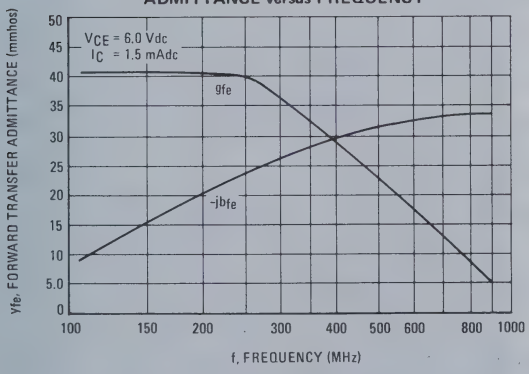


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

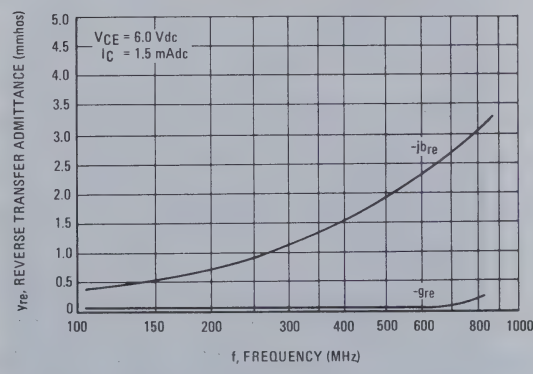


FIGURE 11— S_{11}, INPUT REFLECTION COEFFICIENT

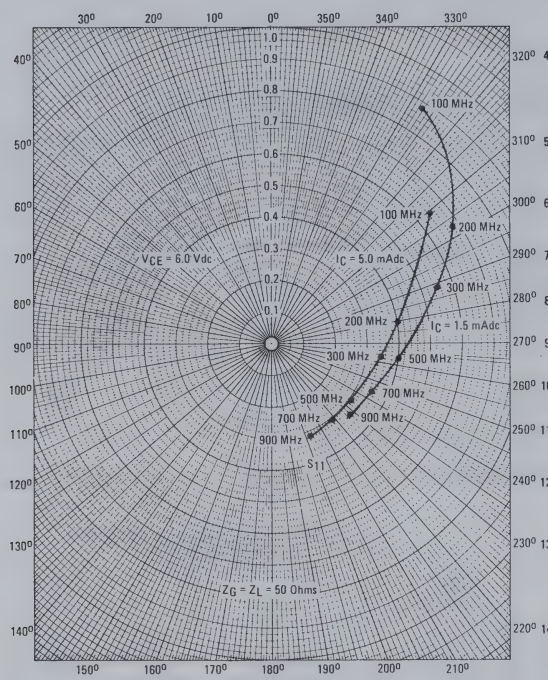


FIGURE 12—S_{22}, OUTPUT REFLECTION COEFFICIENT

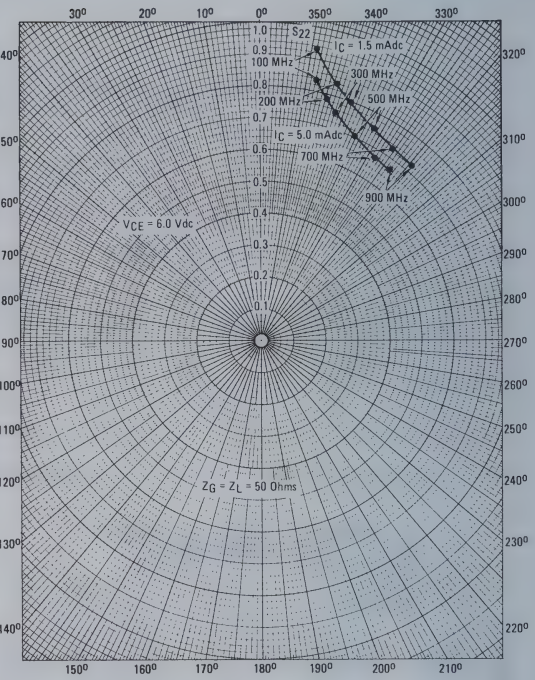


FIGURE 13 —S_{12}, REVERSE TRANSMISSION COEFFICIENT

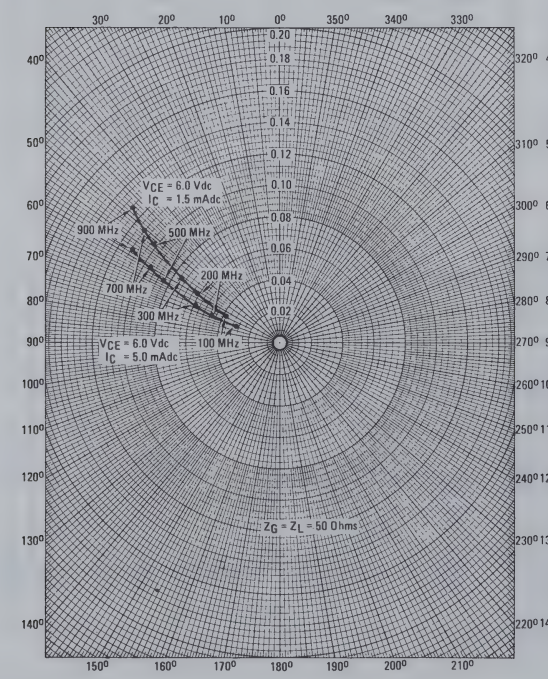


FIGURE 14 —S_{21}, FORWARD TRANSMISSION COEFFICIENT

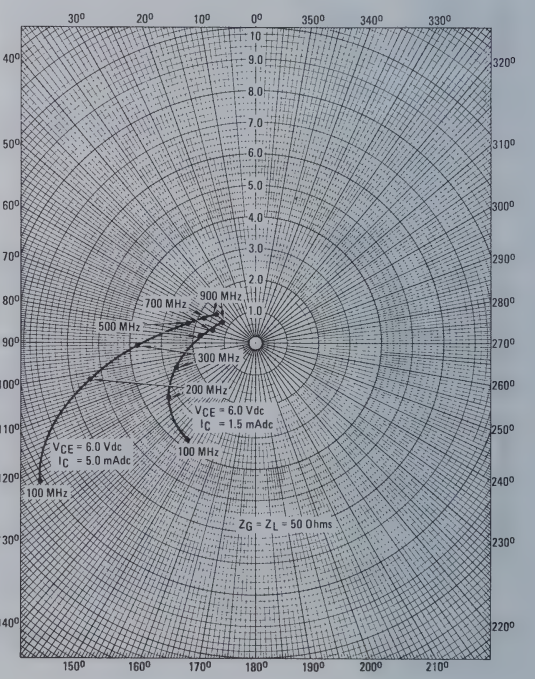
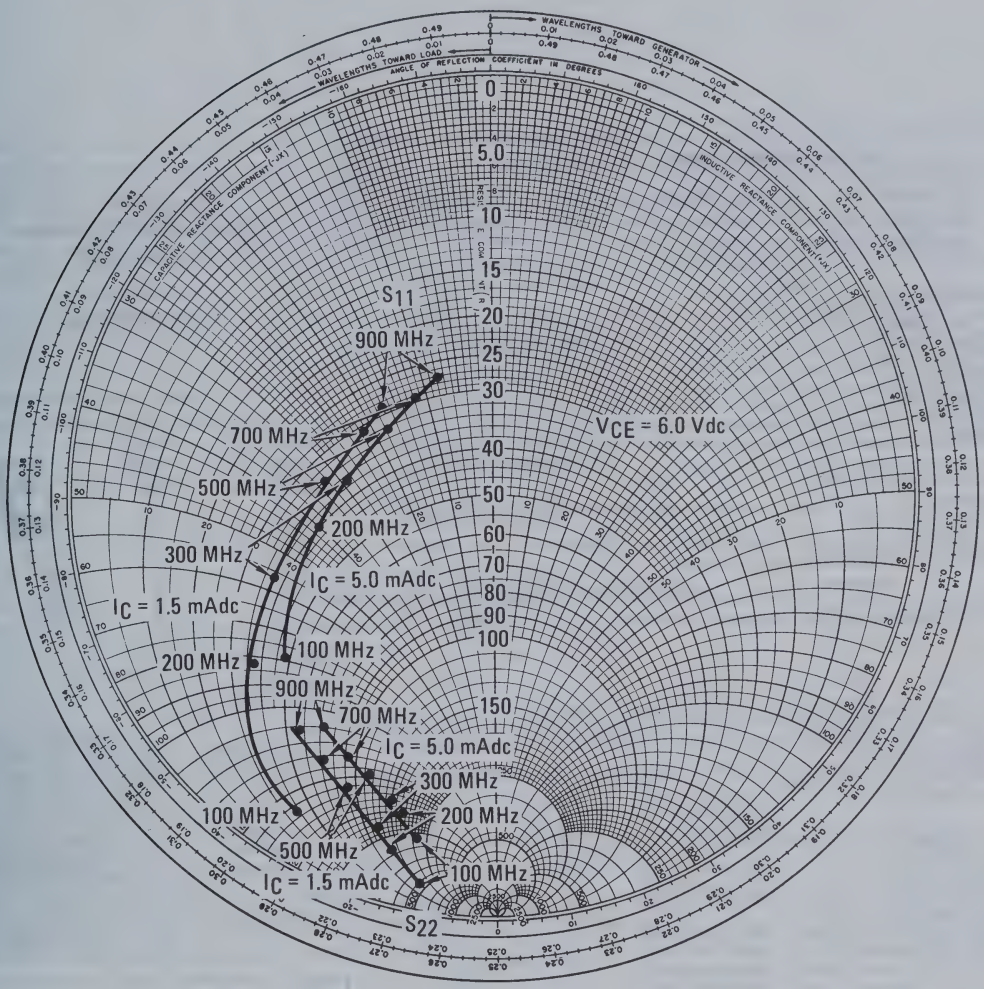


FIGURE 15 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N5190 thru 2N5192 (SILICON)
MJE5190 thru MJE5192

SILICON NPN POWER TRANSISTORS

. . . for use in power amplifier and switching circuits, – excellent safe area limits. Complement to PNP 2N5193, 2N5194, 2N5195 and MJE5193, MJE5194, MJE5195.

4 AMPERE
POWER TRANSISTORS
SILICON NPN

40-80 VOLTS
40 and 60 WATTS

***MAXIMUM RATINGS**

Rating	Symbol	2N5190 MJE5190	2N5191 MJE5191	2N5192 MJE5192	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current	I_C	← 4.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
		2N5190 Series	MJE5190 Series		
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	40 320	60 480		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			^oC

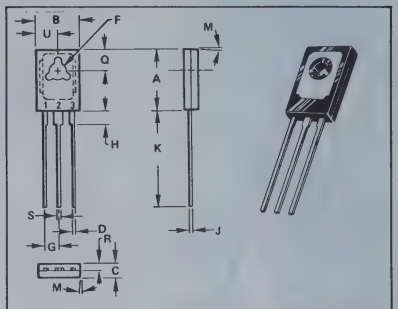
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5190 Series	MJE5190 Series	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	$^oC/W$

***ELECTRICAL CHARACTERISTICS** ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
($I_C = 0.1$ Adc, $I_B = 0$)	2N5190,MJE5190		40	–	
	2N5191,MJE5191		60	–	
	2N5192,MJE5192		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
($V_{CE} = 40$ Vdc, $I_B = 0$)	2N5190,MJE5190		–	1.0	
($V_{CE} = 60$ Vdc, $I_B = 0$)	2N5191,MJE5191		–	1.0	
($V_{CE} = 80$ Vdc, $I_B = 0$)	2N5192,MJE5192		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
($V_{CE} = 40$ Vdc, $V_{EB(off)} = 1.5$ Vdc)	2N5190,MJE5190		–	0.1	
($V_{CE} = 60$ Vdc, $V_{EB(off)} = 1.5$ Vdc)	2N5191,MJE5191		–	0.1	
($V_{CE} = 80$ Vdc, $V_{EB(off)} = 1.5$ Vdc)	2N5192,MJE5192		–	0.1	
($V_{CE} = 40$ Vdc, $V_{EB(off)} = 1.5$ Vdc, $T_C = 125^oC$)	2N5190,MJE5190		–	2.0	
($V_{CE} = 60$ Vdc, $V_{EB(off)} = 1.5$ Vdc, $T_C = 125^oC$)	2N5191,MJE5191		–	2.0	
($V_{CE} = 80$ Vdc, $V_{EB(off)} = 1.5$ Vdc, $T_C = 125^oC$)	2N5192,MJE5192		–	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
($V_{CB} = 40$ Vdc, $I_E = 0$)	2N5190,MJE5190		–	0.1	
($V_{CB} = 60$ Vdc, $I_E = 0$)	2N5191,MJE5191		–	0.1	
($V_{CB} = 80$ Vdc, $I_E = 0$)	2N5192,MJE5192		–	0.1	
Emitter Cutoff Current		I_{EBO}			mAdc
($V_{BE} = 5.0$ Vdc, $I_C = 0$)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
($I_C = 1.5$ Adc, $V_{CE} = 2.0$ Vdc)	2N5190,MJE5190		25	100	
	2N5191,MJE5191		25	100	
	2N5192,MJE5192		20	80	
($I_C = 4.0$ Adc, $V_{CE} = 2.0$ Vdc)	2N5190,MJE5190		10	–	
	2N5191,MJE5191		10		
	2N5192,MJE5192		7.0	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
($I_C = 1.5$ Adc, $I_B = 0.15$ Adc)			–	0.6	
($I_C = 4.0$ Adc, $I_B = 1.0$ Adc)			–	1.4	
Base-Emitter On Voltage(1)		$V_{BE(on)}$			Vdc
($I_C = 1.5$ Adc, $V_{CE} = 2.0$ Vdc)			–	1.2	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product		f_T			MHz
($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc, $f = 1.0$ MHz)			2.0	–	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
* Indicates JEDEC Registered Data for 2N5190 Series.

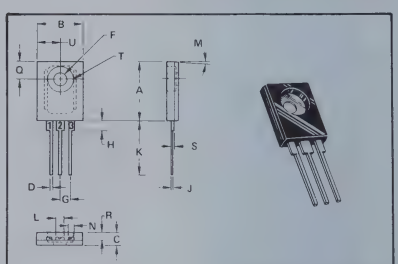


STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

2N5190
2N5191
2N5192

CASE 77-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

MJE5190
MJE5191
MJE5192

CASE 199-04

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

NOTES
1. DIM "G" IS TO CENTER OF LEADS

FIGURE 1 – DC CURRENT GAIN

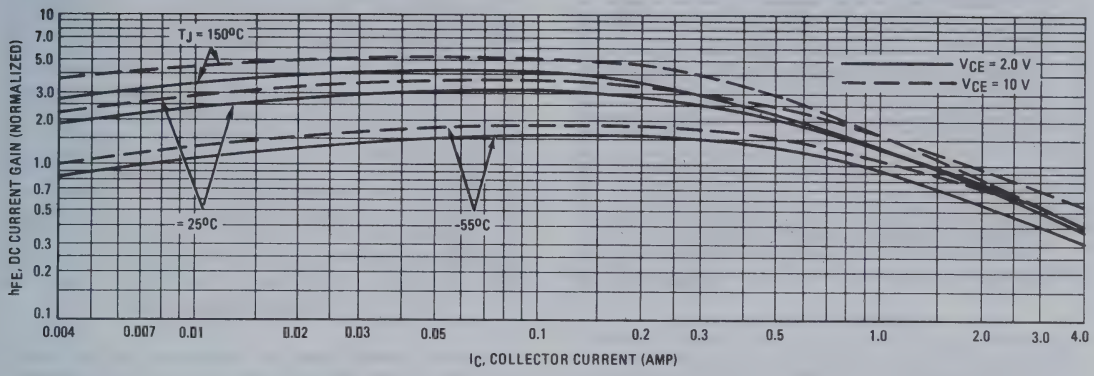


FIGURE 2 – COLLECTOR SATURATION REGION

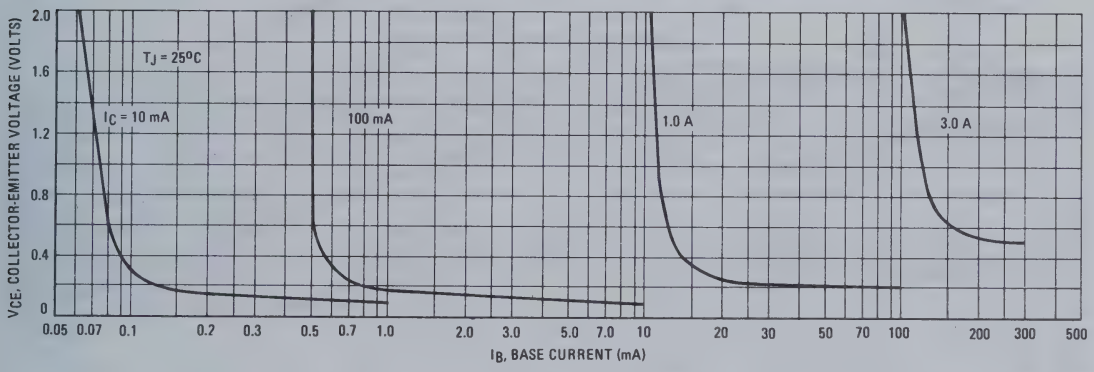


FIGURE 3 – "ON" VOLTAGES

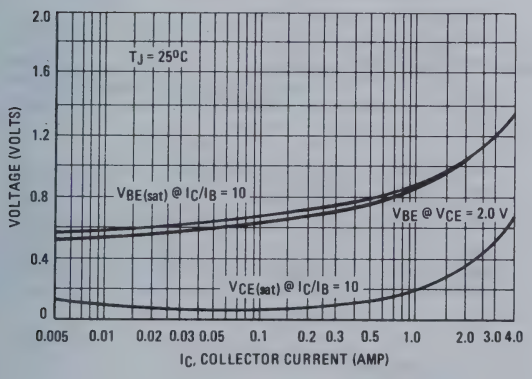


FIGURE 4 – TEMPERATURE COEFFICIENTS

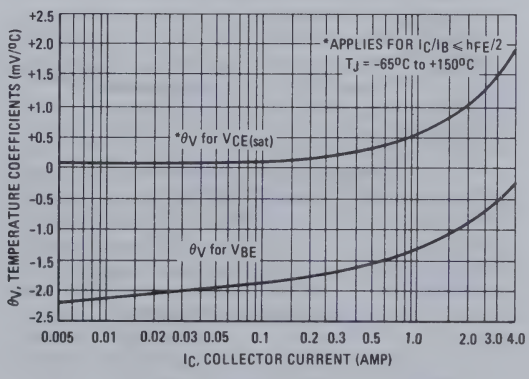


FIGURE 5 – COLLECTOR CUT-OFF REGION

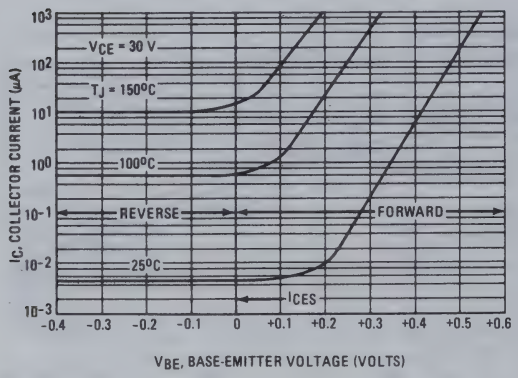


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE

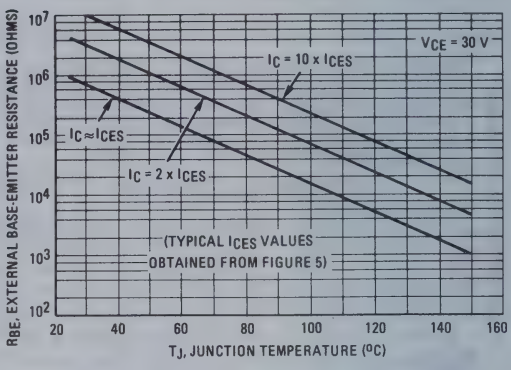


FIGURE 7 – SWITCHING TIME EQUIVALENT CIRCUIT

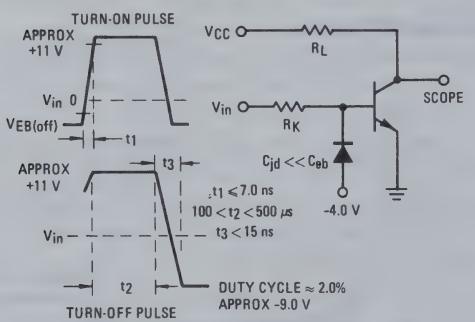


FIGURE 8 – CAPACITANCE

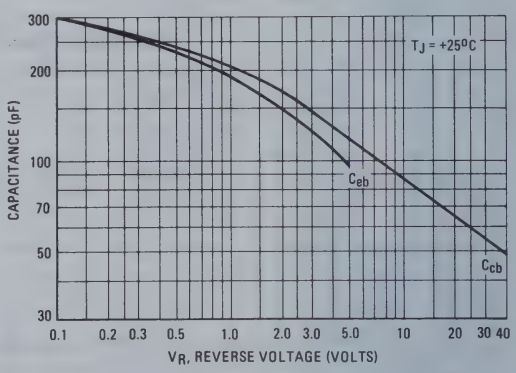


FIGURE 9 – TURN-ON TIME

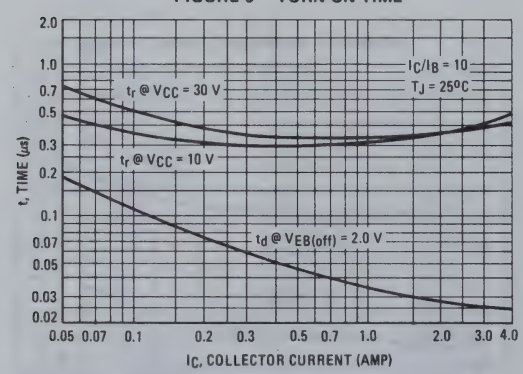
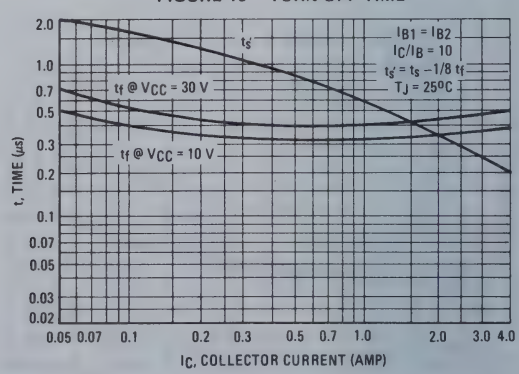


FIGURE 10 – TURN-OFF TIME



RATING AND THERMAL DATA
ACTIVE-REGION SAFE OPERATING AREA

FIGURE 11 – 2N5190,2N5191,2N5192

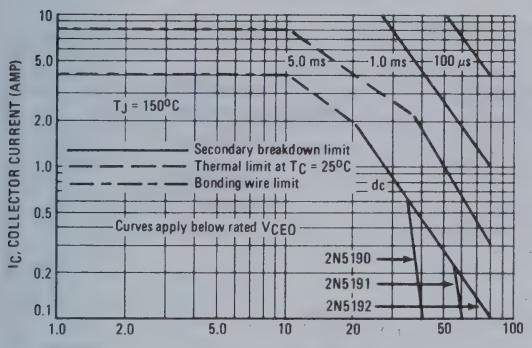
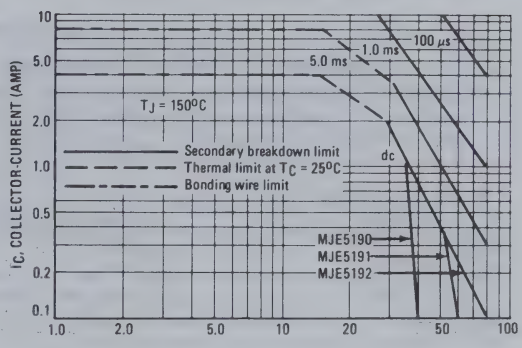


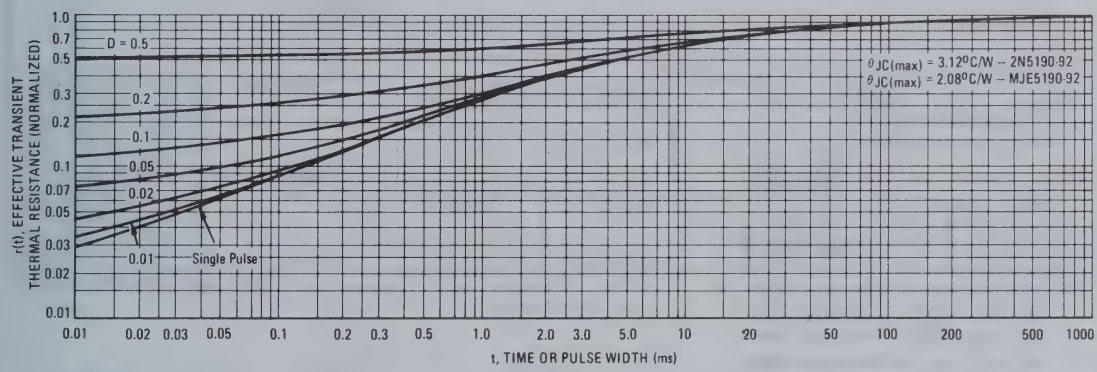
FIGURE 12 – MJE5190, MJE5191, MJE5192



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

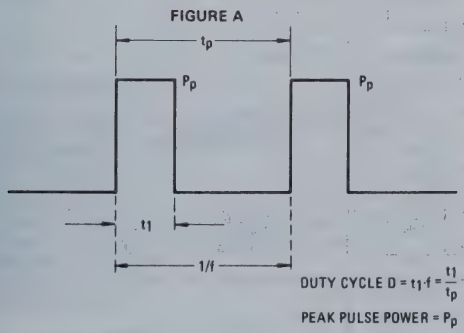
The data of Figures 11 and 12 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 13 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 13 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 13 by the steady state value θ_{JC}.

Example:

The 2N5190 is dissipating 50 watts under the following conditions: t_1 = 0.1 ms, tp = 0.5 ms. (D = 0.2).

Using Figure 13, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore:

$$\triangle T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2°C$$

2N5193 thru 2N5195 (SILICON)
MJE5193 thru MJE5195

SILICON PNP POWER TRANSISTORS

. . . for use in power amplifier and switching circuits, – excellent safe area limits. Complement to NPN 2N5190, 2N5191, 2N5192 and MJE5190, MJE5191, MJE5192.

4 AMPERE POWER TRANSISTORS SILICON PNP

40-80 VOLTS
40 and 60 WATTS

***MAXIMUM RATINGS**

Rating	Symbol	2N5193 MJE5193	2N5194 MJE5194	2N5195 MJE5195	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current	I_C	← 4.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
		2N5193 Series	MJE5193 Series		
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	40 320	60 480		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← –65 to +150 →			^oC/W

THERMAL CHARACTERISTICS

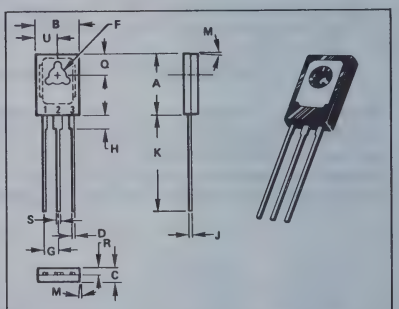
Characteristic	Symbol	2N5193 Series	MJE5193 Series	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	^oC/W

***ELECTRICAL CHARACTERISTICS** ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.1 Adc, I_B = 0)	2N5193, MJE5193		40	–	
	2N5194, MJE5194		60	–	
	2N5195, MJE5195		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5193, MJE5193		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5194, MJE5194		–	1.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5195, MJE5195		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5193, MJE5193		–	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5194, MJE5194		–	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5195, MJE5195		–	0.1	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5193, MJE5193		–	2.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5194, MJE5194		–	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5195, MJE5195		–	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5193, MJE5193		–	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	2N5194, MJE5194		–	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N5195, MJE5195		–	0.1	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)	2N5193, MJE5193, 2N5194, MJE5194, 2N5195, MJE5195		25	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	2N5193, MJE5193,		20	80	
	2N5194, MJE5194,		10	–	
	2N5195, MJE5195		7.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			–	0.6	
(I_C = 4.0 Adc, I_B = 1.0 Adc)			–	1.2	
Base-Emitter On Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			–	1.2	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product		f_T			MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)			2.0	–	

*Indicates JEDEC Registered Data for 2N5193 Series.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

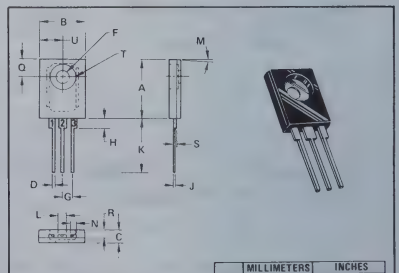


STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

2N5193
2N5194
2N5195

CASE 77-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	30° TYP		30° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

MJE5193
MJE5194
MJE5195

CASE 199-04

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	30° TYP		30° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

NOTES:
1. DIM "G" IS TO CENTER OF LEADS

FIGURE 1 – DC CURRENT GAIN

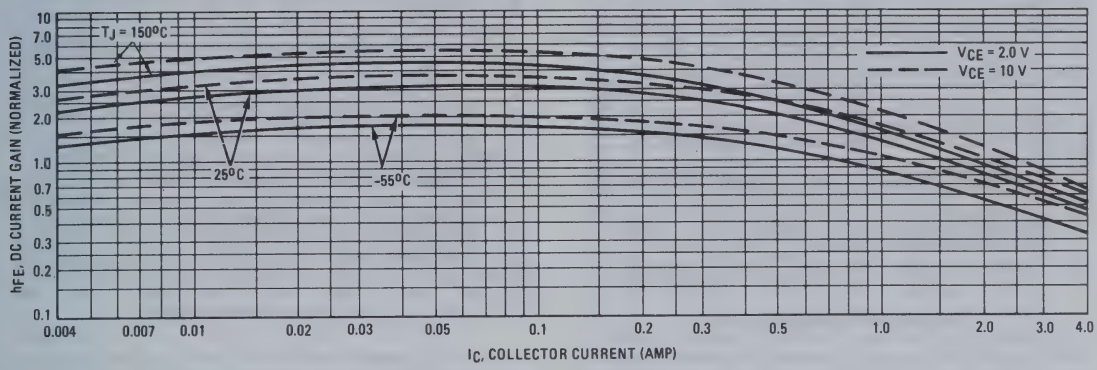


FIGURE 2 – COLLECTOR SATURATION REGION

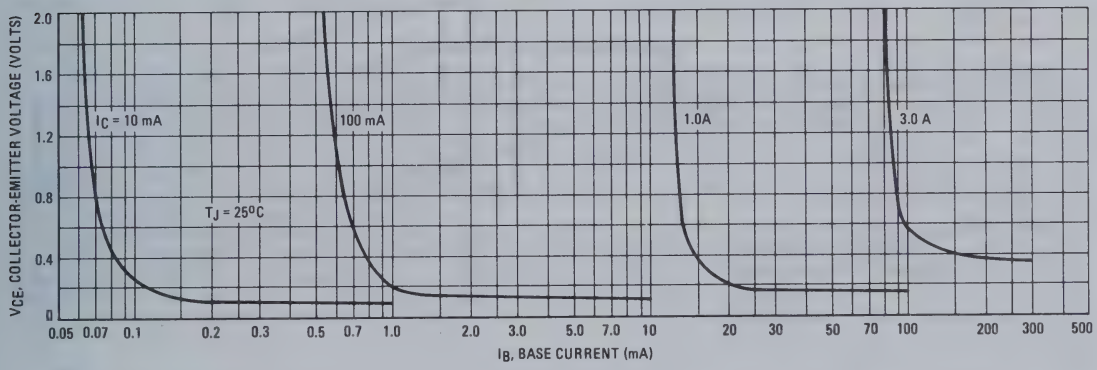


FIGURE 3 – "ON" VOLTAGE

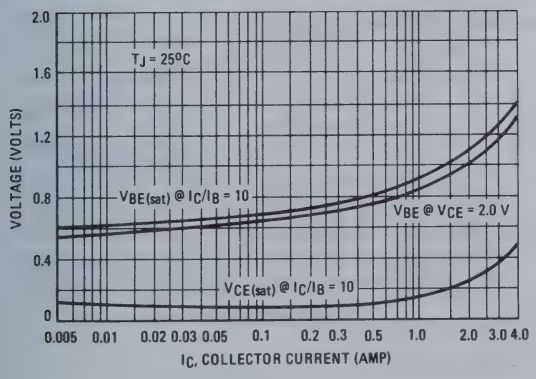


FIGURE 4 – TEMPERATURE COEFFICIENTS

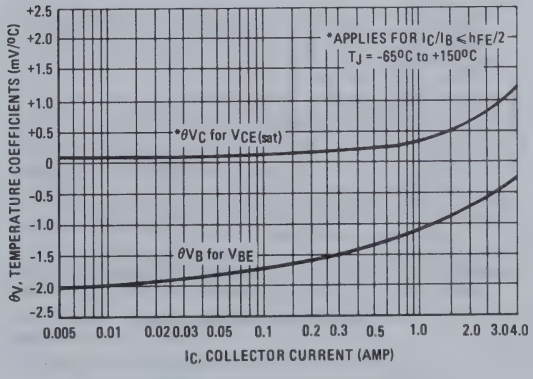


FIGURE 5 – COLLECTOR CUT-OFF REGION

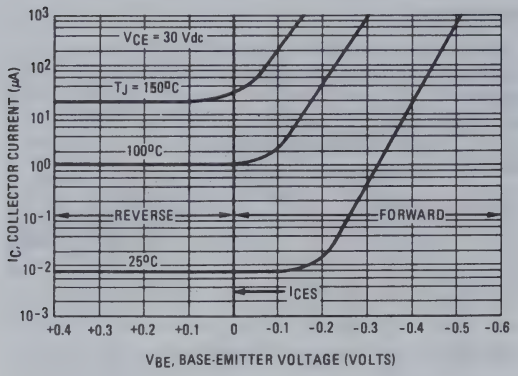


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE

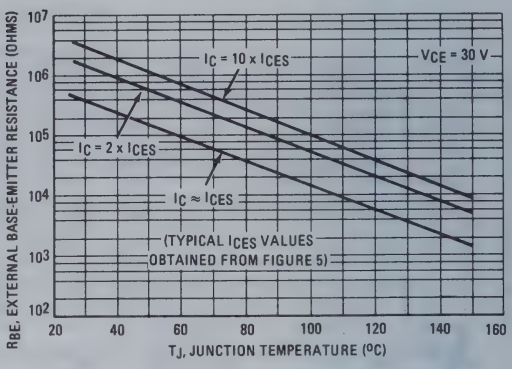


FIGURE 7 – SWITCHING TIME EQUIVALENT CIRCUIT

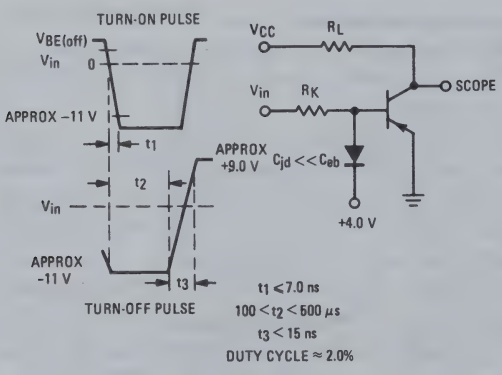


FIGURE 8 – CAPACITANCE

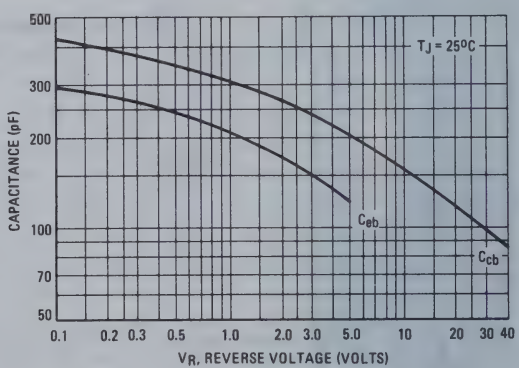


FIGURE 9 – TURN-ON TIME

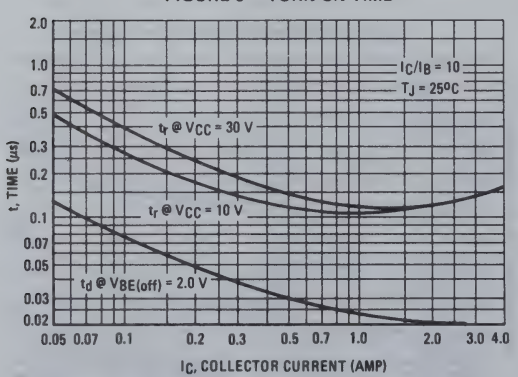
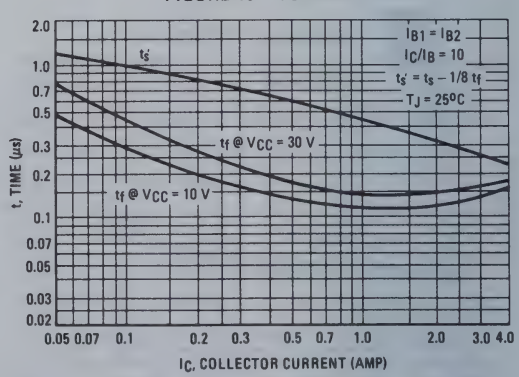


FIGURE 10 – TURN-OFF TIME



RATING AND THERMAL DATA
ACTIVE-REGION SAFE OPERATING AREA

FIGURE 11 – 2N5193, 2N5194, 2N5195

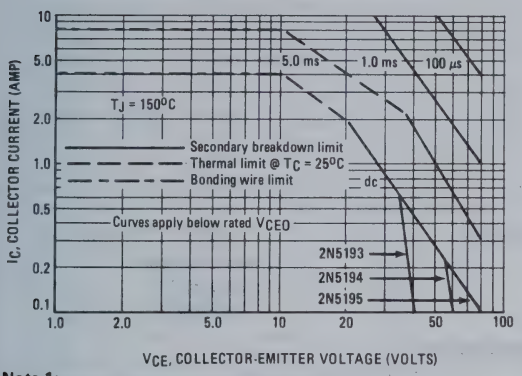
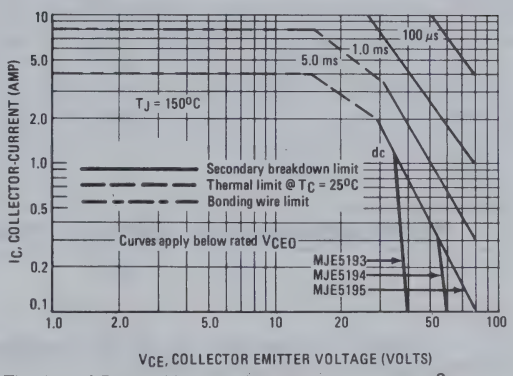


FIGURE 12 – MJE5193, MJE5194, MJE5195

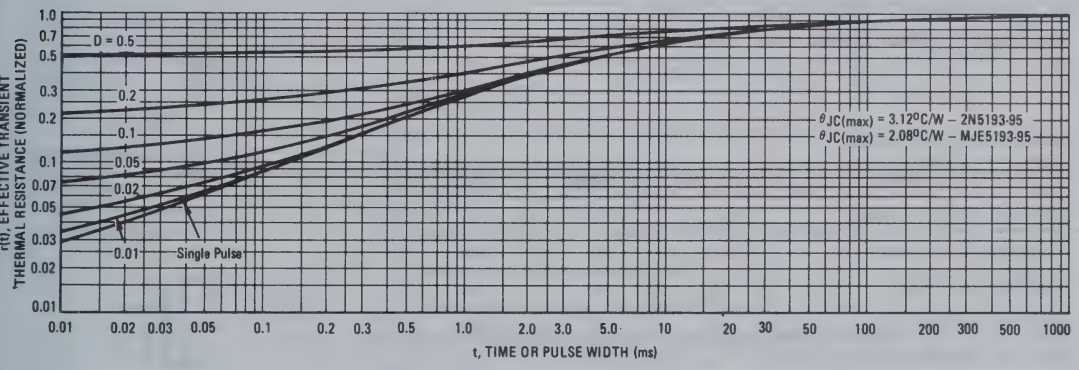


Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

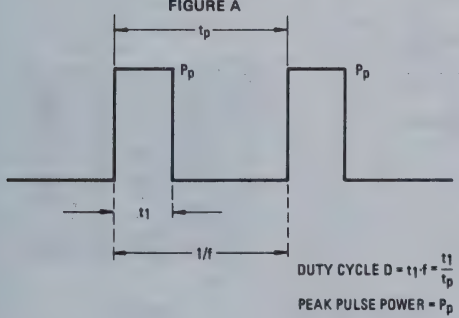
The data of Figures 11 and 12 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 13 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 13 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 13 by the steady state value θ_{JC}.

Example:

The 2N5193 is dissipating 50 watts under the following conditions: $t_1 = 0.1$ ms, $t_p = 0.5$ ms. (D = 0.2).

Using Figure 13, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore:

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2^oC$$

2N5208 (SILICON)

PNP SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general purpose RF amplifier applications in the frequency range up to 300 MHz.

- Low Collector-Base Time Constant – $r_b'C_c$ < 10 ps
- Low Noise Figure N.F. = 3.0 dB max @ 100 MHz
- High Power Gain – G_{pe} = 22 dB min @ 100 MHz
- Complete Y-Parameter Curves
- Low Leakage Current – I_{CBO} < 10 nAdc
- Stability Factor Curves - For Direct Circuit Design

PNP SILICON ANNULAR TRANSISTOR

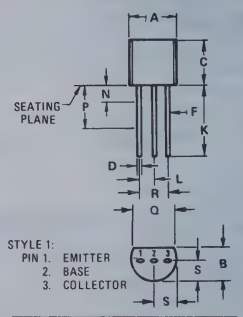


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



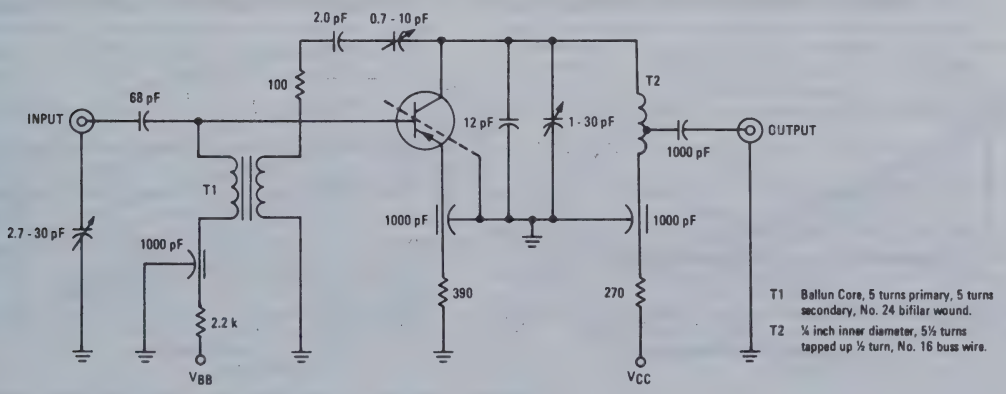
DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	10	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	120	-
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	1200	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	1.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	4.0	pF
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	10	ps
Noise Figure (See Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz, BW = 1.0 MHz)	NF	-	3.0	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	G_{pe}	22	-	dB

FIGURE 1 - 100 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



COMMON-EMITTER Y PARAMETERS (Polar Plots)

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 2 - INPUT ADMITTANCE

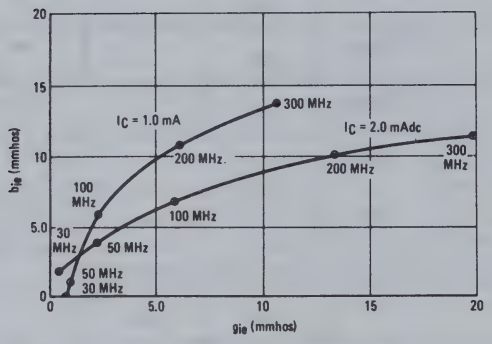


FIGURE 3 - OUTPUT ADMITTANCE

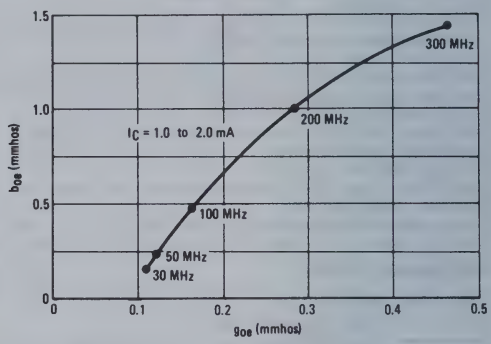


FIGURE 4 - FORWARD TRANSFER ADMITTANCE

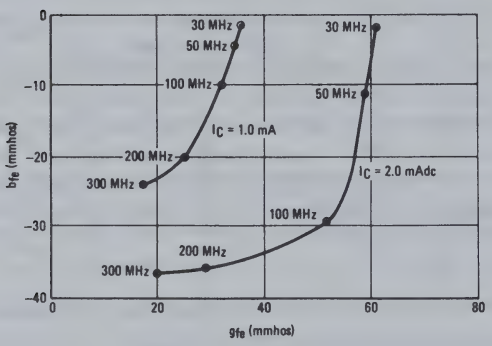
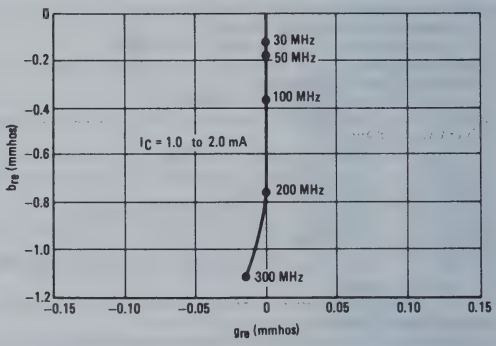


FIGURE 5 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVE

FIGURE 6 - POWER GAIN AND NOISE FIGURE

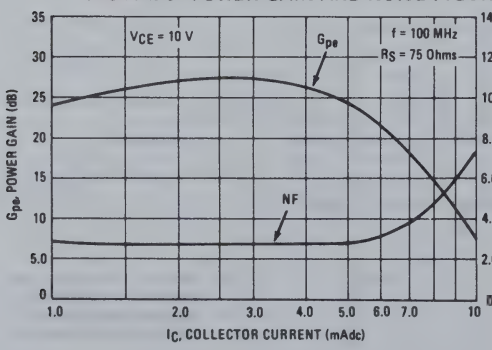
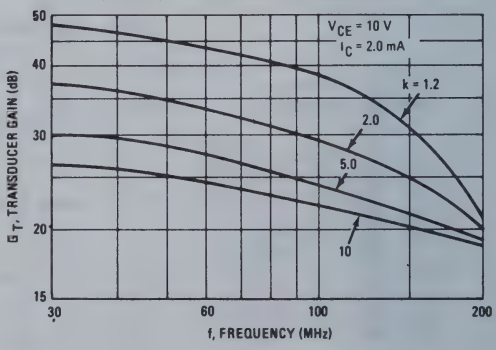


FIGURE 7 - MAXIMUM TRANSDUCER GAIN



COMMON-EMITTER Y PARAMETERS vs FREQUENCY

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 8 - INPUT ADMITTANCE

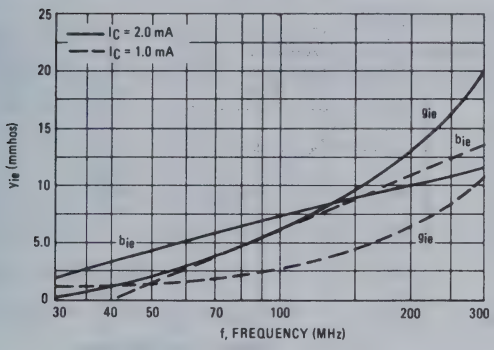


FIGURE 9 - OUTPUT ADMITTANCE

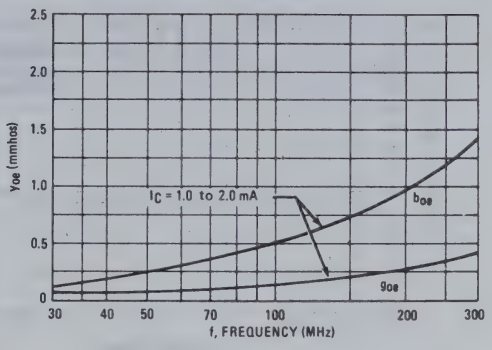


FIGURE 10 - FORWARD TRANSFER ADMITTANCE

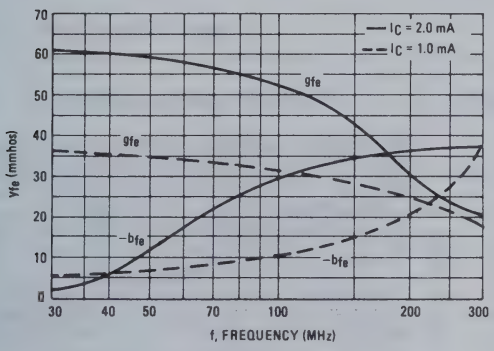
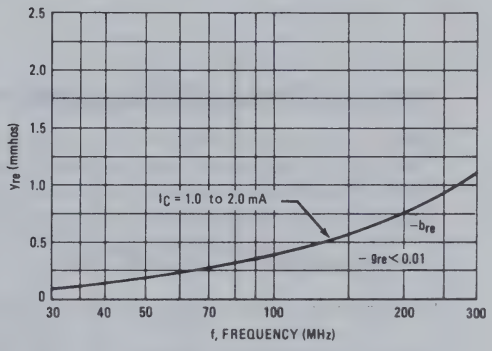


FIGURE 11 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVES

FIGURE 12 - OPTIMUM SOURCE ADMITTANCE

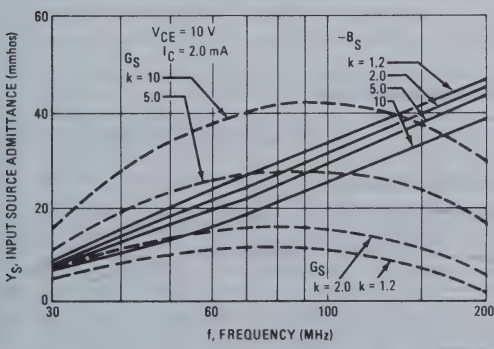
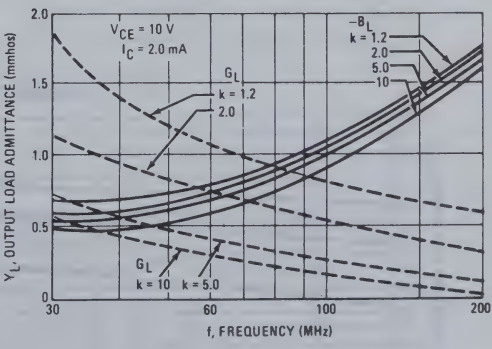


FIGURE 13 - OPTIMUM LOAD ADMITTANCE



When a potentially unstable device is operated without feedback, there is an infinite number of combinations of source and load admittance associated with any given circuit stability factor (k). Equations have been developed for determining the optimum source and load admittance for maximum gain. Figures 7, 12 and 13 provide a solution to the equations for the 2N5208.

NOISE FIGURE

FIGURE 14 - FREQUENCY EFFECTS

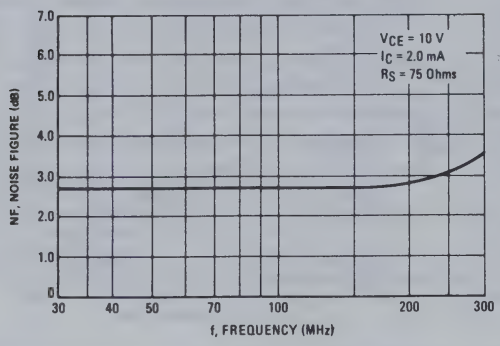


FIGURE 15 - SOURCE RESISTANCE EFFECTS

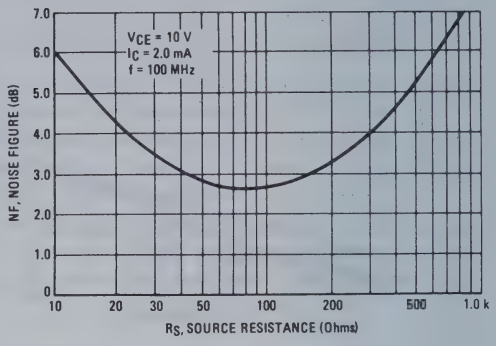


FIGURE 16 - CURRENT-GAIN — BANDWIDTH PRODUCT

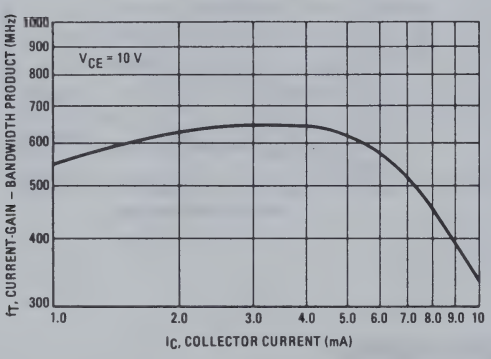


FIGURE 17 - CAPACITANCES

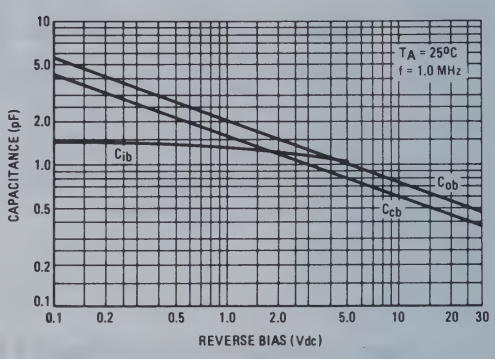
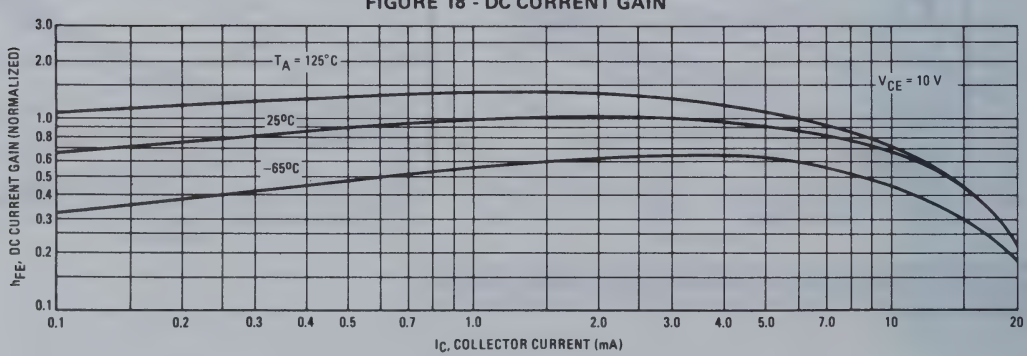


FIGURE 18 - DC CURRENT GAIN



2N5209 (SILICON)
2N5210



NPN silicon annular transistors designed for low-level, low-noise amplifier applications and for complementary circuitry with PNP types 2N5086 and 2N5087.

CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 10 Vdc, I_E = 0)			-	-	10	
(V_{CB} = 35 Vdc, I_E = 0)			-	-	50	
Emitter Cutoff Current		I_{EBO}				nAdc
(V_{BE} = 3.0 Vdc, I_C = 0)			-	-	50	
(V_{BE} = 4.5 Vdc, I_C = 0)			-	-	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5209		100	-	300	
	2N5210		200	-	600	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5209		150	-	-	
	2N5210		250	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5209		150	-	-	
	2N5210		250	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	80	-	MHz
Collector Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz) (emitter guarded)		C_{cb}	-	-	4.0	pF
Small-Signal Current Gain		h_{fe}				-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5209		150	-	600	
	2N5210		250	-	900	
Noise Figure		NF				dB
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 22 k ohms,	2N5209		-	-	3.0	
f = 10 Hz to 15.7 kHz)	2N5210		-	-	2.0	
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms,	2N5209		-	1.6	4.0	
f = 1.0 kHz)	2N5210		-	1.4	3.0	

*Indicates JEDEC Registered Data

NOISE FIGURE
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE FIGURE versus FREQUENCY

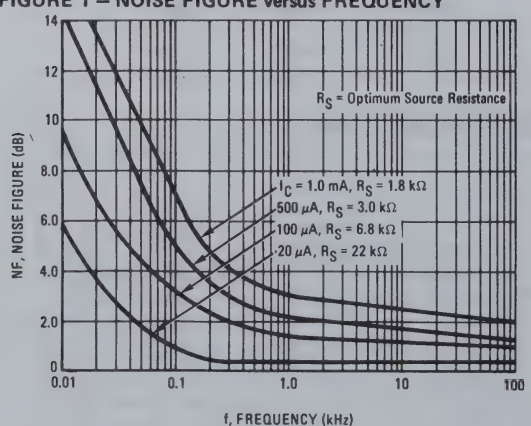
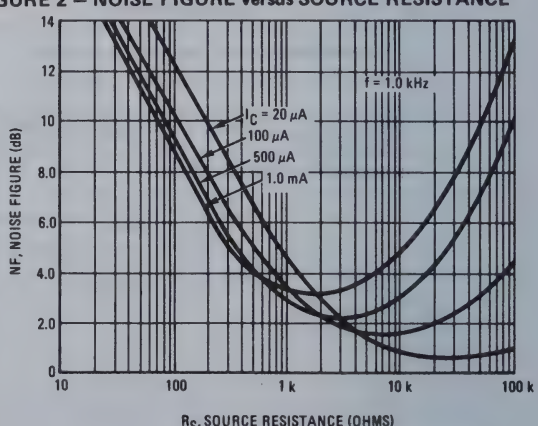


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE versus COLLECTOR CURRENT

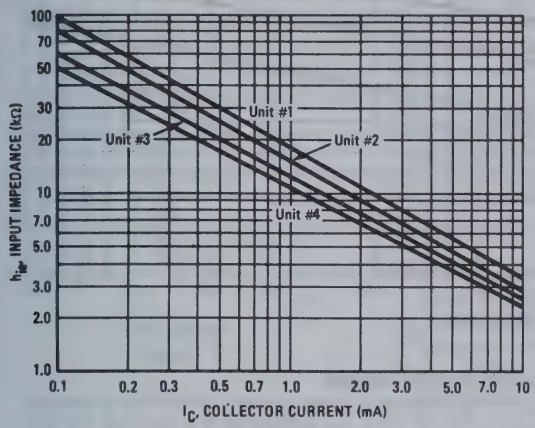


FIGURE 4 — VOLTAGE FEEDBACK RATIO versus COLLECTOR CURRENT

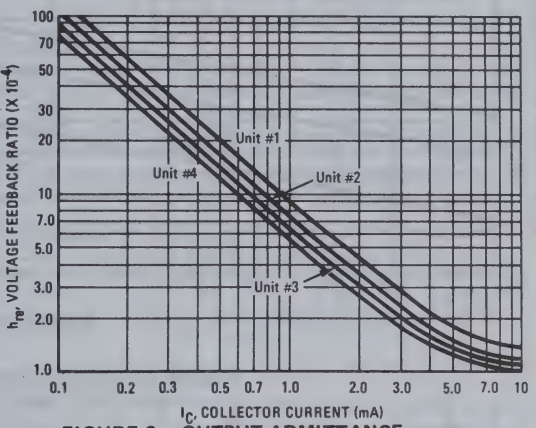


FIGURE 5 — CURRENT GAIN versus COLLECTOR CURRENT

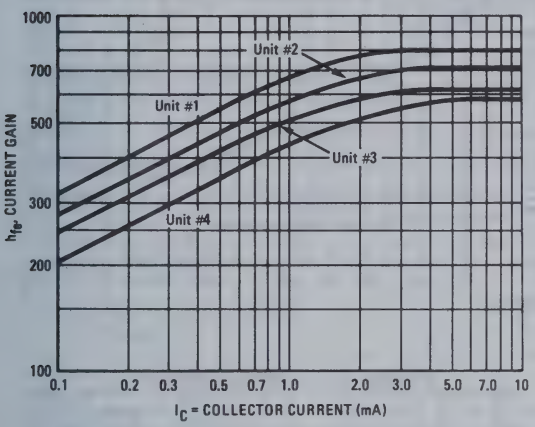


FIGURE 6 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

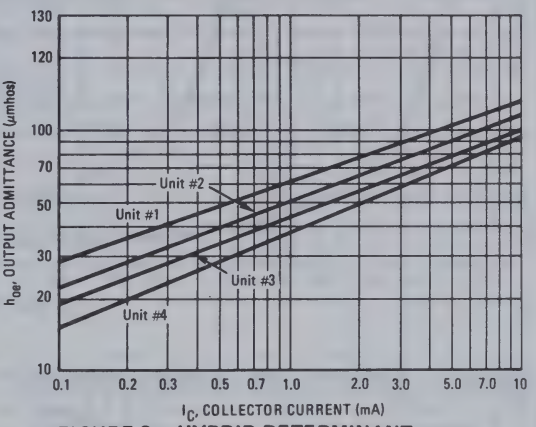


FIGURE 7 — EFFECT OF VOLTAGE

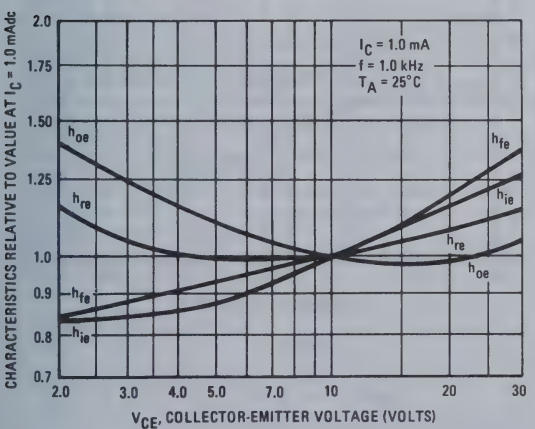


FIGURE 8 — HYBRID DETERMINANT versus COLLECTOR CURRENT

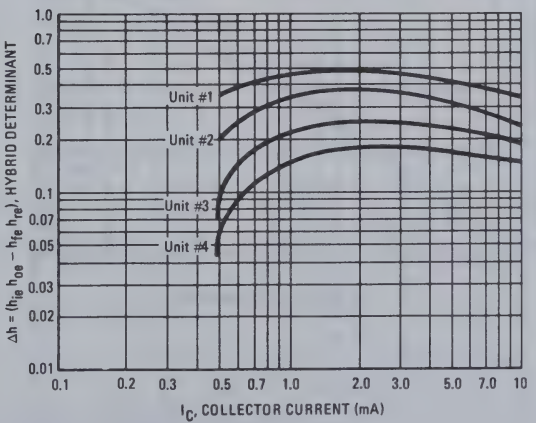


FIGURE 9 – DC CURRENT GAIN

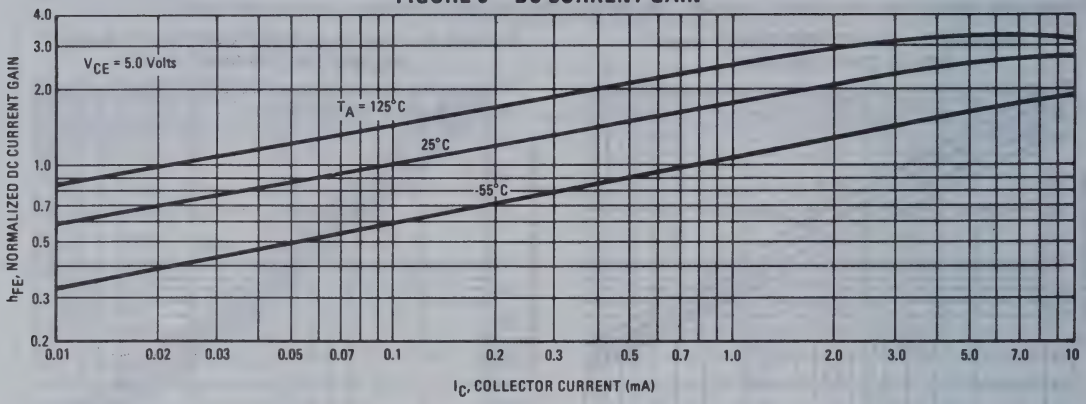


FIGURE 10 – COLLECTOR SATURATION REGION

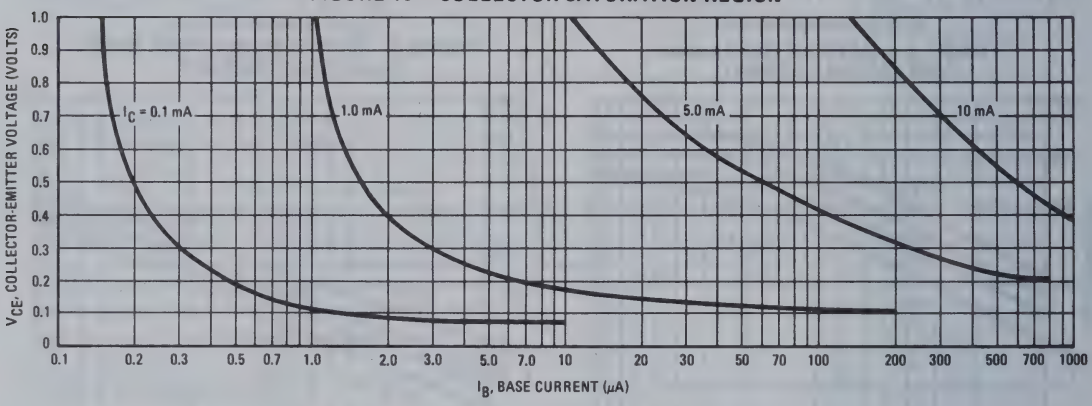


FIGURE 11 – CURRENT-GAIN – BANDWIDTH PRODUCT

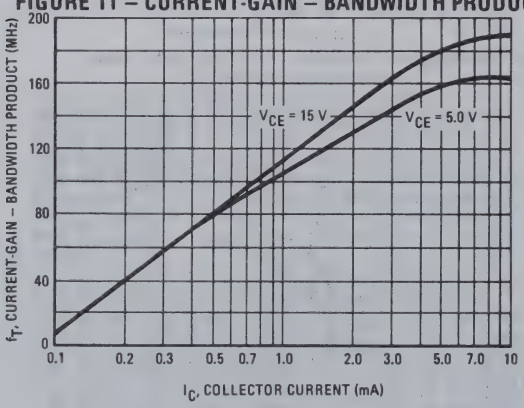
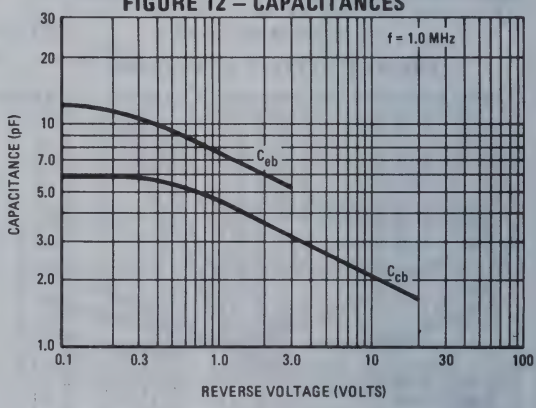


FIGURE 12 – CAPACITANCES



2N5219 (SILICON)

NPN silicon annular transistor designed for low-level, small-signal, general-purpose amplifier and oscillator applications.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	35	500	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	150	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	35	1500	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

2N5220 (SILICON)

NPN silicon annular transistor designed for low-power, large-signal audio and general-purpose amplifier applications and for complementary circuitry with PNP type 2N5221.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	10	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

*Indicates JEDEC Registered Data

2N5221 (SILICON)

PNP silicon annular transistor designed for low-power, large-signal audio and general-purpose amplifier applications, and for complementary circuitry with NPN type 2N5220.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

2N5222 (SILICON)

NPN silicon annular transistor designed for RF amplifier, mixer, and video IF applications in AM/FM radio and television receivers.



CASE 29-02
TO-92

Style 2:
Pin 1. Base
2. Emitter
3. Collector

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	1500	-
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 400 μAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 400 μAdc)	$V_{BE(sat)}$	-	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc	f_T	450	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	1.3	pF
Small-Signal Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	3000	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

*Indicates JEDEC Registered Data

2N5223 (SILICON)

NPN silicon annular transistor designed for low-level, small-signal, general-purpose amplifier and oscillator applications.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	50	800	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	150	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1600	-

*Indicates JEDEC Registered Data

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

2N5224 (SILICON)

NPN silicon annular transistor designed for general-purpose, low-level switching applications.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

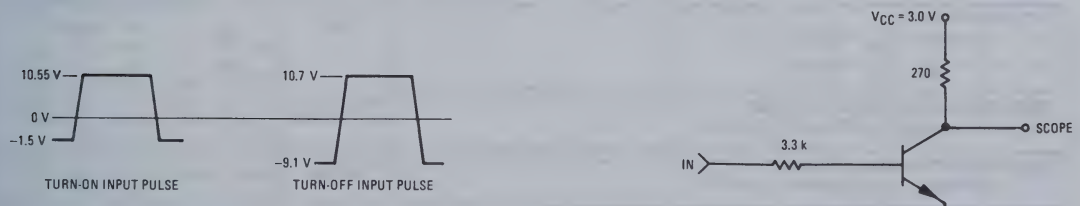
(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = –65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40 15	400 -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	-	25	ns
Rise Time (See Figure 1)	t_r	-	20	ns
Storage Time (See Figure 1)	t_s	-	35	ns
Fall Time (See Figure 1)	t_f	-	25	ns

[1] Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



GENERATOR SOURCE IMPEDANCE = 50 ohms

INPUT PULSE:
- RISE TIME ≤ 2.0 ns
- FALL TIME ≤ 2.0 ns
- NOMINAL PULSEWIDTH = 300 ns
- NOMINAL DUTY CYCLE = 2.0%

OSCILLOSCOPE:
- RISE TIME ≤ 0.4 ns
- INPUT RESISTANCE ≥ 50 ohms
- INPUT CAPACITANCE ≤ 4.0 pF

2N5225 (SILICON)

NPN silicon annular transistor designed for medium-current amplifier applications and for complementary circuitry with PNP type 2N5226.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

*Indicates JEDEC Registered Data

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

2N5226 (SILICON)

PNP silicon annular transistor designed for medium-current, amplifier applications and for complementary circuitry with NPN type 2N5225.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25 30	- 600	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

2N5227 (SILICON)

PNP silicon annular transistor designed for low-level, small-signal general-purpose amplifier and oscillator applications.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30 50	- 700	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{cb}	-	5.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1500	-

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

*Indicates JEDEC Registered Data

2N5228 (SILICON)



PNP silicon annular transistor designed for general-purpose, low level switching applications.

CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

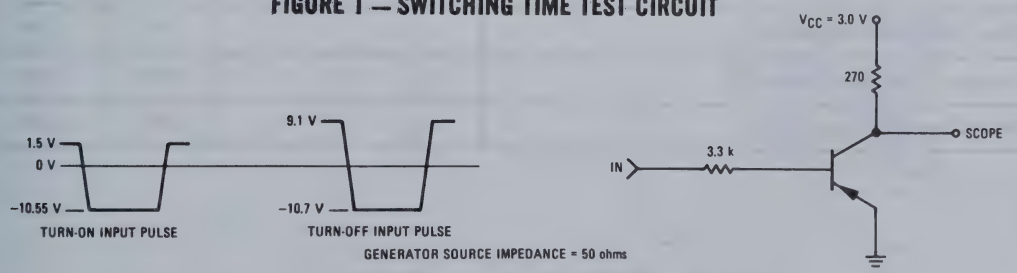
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Emitter Voltage	V_{CES}	6.0	Vdc
Collector-Base Voltage	V_{CB}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



GENERATOR SOURCE IMPEDANCE = 50 ohms

INPUT PULSE:
RISE TIME < 2.0 ns
FALL TIME < 2.0 ns
NOMINAL PULSEWIDTH = 300 ns
NOMINAL DUTY CYCLE = 2.0%

OSCILLOSCOPE:
RISE TIME < 0.4 ns
INPUT RESISTANCE > 50 ohms
INPUT CAPACITANCE < 4.0 pF

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	5.0	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	6.0	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	5.0	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, V_{BE} = 0)	I_{CES}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 15	- -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.65	1.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	300	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	-	25	ns
Rise Time (See Figure 1)	t_r	-	50	ns
Storage Time (See Figure 1)	t_s	-	90	ns
Fall Time (See Figure 1)	t_f	-	50	ns

2N5229 (SILICON)
2N5230
2N5231

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, chopper applications requiring high speed operation. This series of devices offers excellent characteristics for use in servo-loop, sensing instrumentation and control amplifier for motor drive systems. These transistors can also be used as replacement devices for alloy-type transistors where high BV_{EBO} is required.

- Low Offset Voltage – $V_{EC(off)}$ = 0.5 mVdc (Max) @ I_B = 100 μAdc
- Low Dynamic "ON" Series Resistance – $r_{ec(ON)}$ = 6.0 Ohms (Max) @ I_B = 1.0 mAdc
- Space Saving TO-46 Package

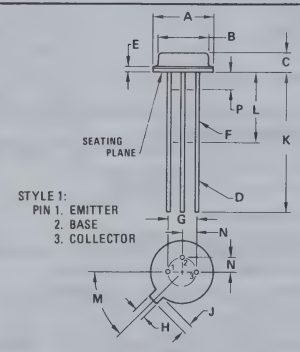
PNP SILICON CHOPPER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	2N5229	2N5230	2N5231	Unit
*Collector-Emitter Voltage	V_{CEO}	10	20	30	Vdc
*Collector-Base Voltage	V_{CB}	15	30	50	Vdc
*Emitter-Base Voltage	V_{EB}	15	30	50	Vdc
*Collector Current – Continuous	I_C	← 50 →			mAdc
Total Device Dissipation @ T_A = 25°C	P_D	← 0.5 →			Watt
Derate above 25°C		← 2.86 →			mW/°C
*Total Device Dissipation @ T_C = 25°C	P_D	← 2.0 →			Watts
Derate above 25°C		← 12 →			mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← −65 to +200 →			°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage		BV_{ECO}			Vdc
(I_E = 10 μAdc, I_B = 0)	2N5229		10	–	
	2N5230		20	–	
	2N5231		30	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N5229		15	–	
	2N5230		30	–	
	2N5231		50	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)	2N5229		15	–	
	2N5230		30	–	
	2N5231		50	–	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 12 Vdc, I_E = 0)	2N5229		–	1.0	
(V_{CB} = 25 Vdc, I_E = 0)	2N5230		–	1.0	
(V_{CB} = 40 Vdc, I_E = 0)	2N5231		–	1.0	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 12 Vdc, I_C = 0)	2N5229		–	1.0	
(V_{EB} = 25 Vdc, I_C = 0)	2N5230		–	1.0	
(V_{EB} = 40 Vdc, I_C = 0)	2N5231		–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)			50	–	
(I_C = 200 μAdc, V_{CE} = 0.5 Vdc) (Inverted Connection)			15	–	
Offset Voltage		$V_{EC(off)}$			mVdc
(I_B = 100 μAdc, I_E = 0)	2N5229,2N5230		–	0.5	
	2N5231		–	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N5229		–	0.8	
	2N5230,2N5231		–	1.0	
DYNAMIC CHARACTERISTICS					
Collector-Base Capacitance		C_{cb}	–	5.0	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)					
Emitter-Base Capacitance		C_{eb}	–	4.0	pF
(V_{EB} = 10 Vdc, I_C = 0, f = 140 kHz)					
Small-Signal Current Gain		h_{fe}	2.0	–	–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 4.0 MHz)					
"ON" Series Resistance		r_{ec} (ON)			Ohms
(I_B = 1.0 mAdc, I_E = 0, I_e = 100 μA RMS, f = 1.0 kHz)	2N5229		1.0	6.0	
	2N5230		2.0	8.0	
	2N5231		2.0	10	

*Indicates JEDEC Registered Data.

TYPICAL CHARACTERISTICS

FIGURE 1 – EMITTER-COLLECTOR VOLTAGE versus BASE CURRENT

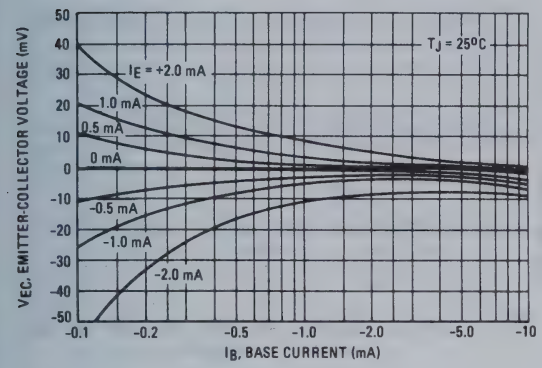


FIGURE 2 – EMITTER-COLLECTOR VOLTAGE versus JUNCTION TEMPERATURE

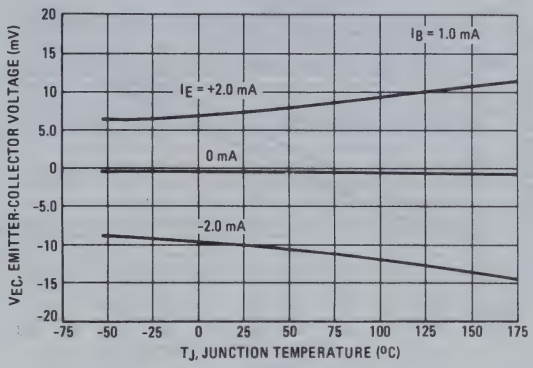


FIGURE 3 – EMITTER-COLLECTOR "ON" RESISTANCE versus BASE CURRENT

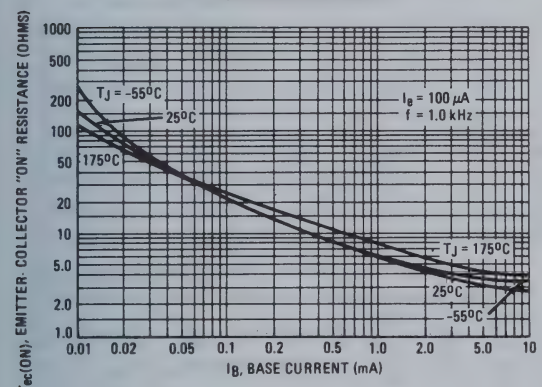


FIGURE 4 – EMITTER-COLLECTOR "ON" RESISTANCE TEMPERATURE COEFFICIENT versus BASE CURRENT

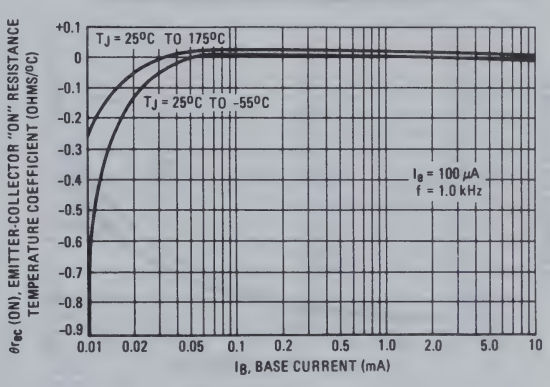


FIGURE 5 – CURRENT GAIN versus COLLECTOR CURRENT

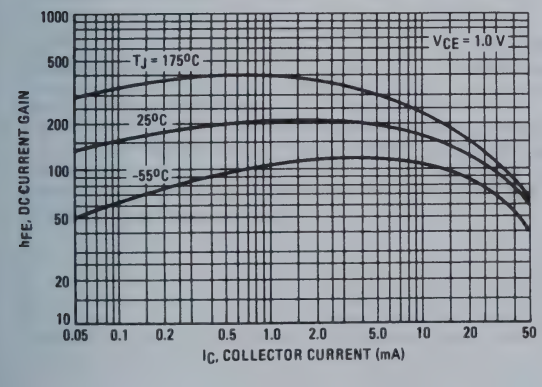


FIGURE 6 – CURRENT GAIN (Inverted Connection) versus EMITTER CURRENT

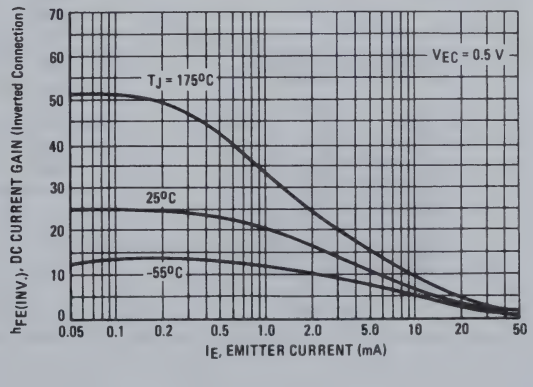


FIGURE 7 – COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE

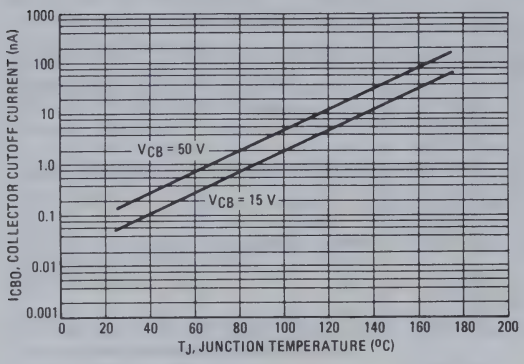


FIGURE 8 – EMITTER CUTOFF CURRENT versus JUNCTION TEMPERATURE

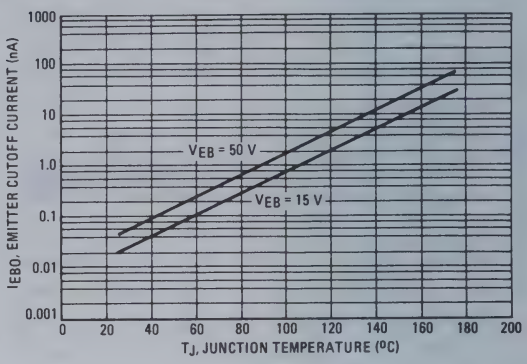


FIGURE 9 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

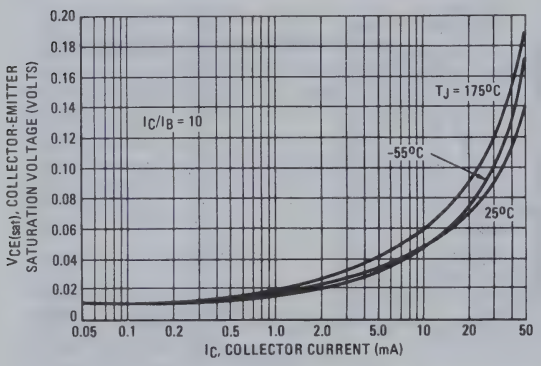
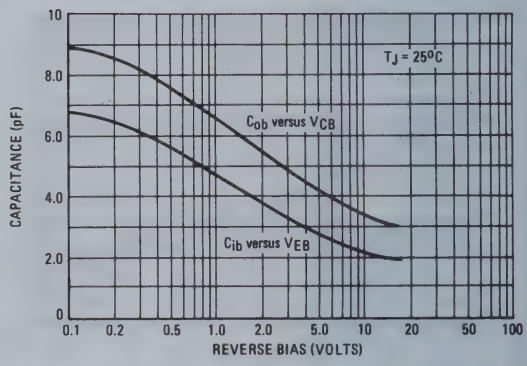


FIGURE 10 – JUNCTION CAPACITANCE versus REVERSE BIAS VOLTAGE



2N5241 (SILICON)

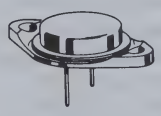
HIGH VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in high-voltage switching regulators, inverters, converters and line operated amplifiers.

- High Collector-Emitter Voltage — 400 Volts
- DC Current Gain —
  h_{FE} = 10 (Min) @ I_C = 3.5 Adc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 2.5 Adc
- Switching Times — @ I_C = 2.5 Adc
  t_{on} = 0.8 μs (Max)
  t_{off} = 1.7 μs (Max)

5.0 AMPERE
POWER TRANSISTOR
NPN SILICON

400 VOLTS
125 WATTS



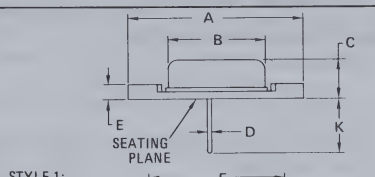
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	400	Vdc
Collector-Base Voltage	V_{CB}	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	5.0	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 62.5°C Derate above 62.5°C	P_D	125 1.43	Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	°C/W

*Indicates JEDEC Registered Data



NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	$BV_{CEO(sus)}$	325	–	Vdc
Collector Cutoff Current (V_{CE} = 400 Vdc, I_B = 0)	I_{CEO}	–	2.5	mAdc
Collector Cutoff Current	I_{CEX}			mAdc
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		–	0.5	
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		15	35	
(I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 2.5 Adc, I_B = 0.5 Adc)		–	0.7	
(I_C = 5.0 Adc, I_B = 1.0 Adc)		–	2.5	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 2.5 Adc, I_B = 0.5 Adc)		–	1.5	
(I_C = 5.0 Adc, I_B = 1.0 Adc)		–	2.0	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 12 Vdc, f = 1.0 MHz)	f_T	2.5	–	MHz
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 125 Vdc, I_C = 2.5 Adc, I_{B1} = 0.25 Adc)	t_{on}	–	0.8	μs
Turn-Off Time (V_{CC} = 125 Vdc, I_C = 2.5 Adc, I_{B1} = 0.25 Adc, I_{B2} = 0.5 Adc)	t_{off}	–	1.7	μs
Pulse Energy Test (V_{CC} = 200 Vdc, I_C = 0.3 Adc, t_p = 5.0 ms, Duty Cycle = 1.0%)	–	300	–	mJ

FIGURE 1 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUIT AND WAVEFORM

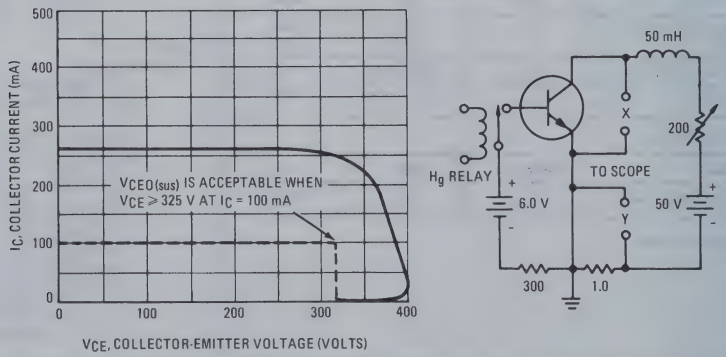
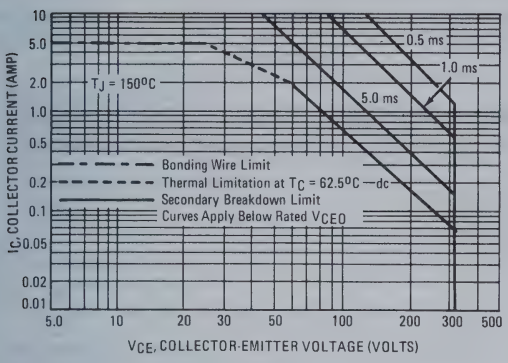


FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

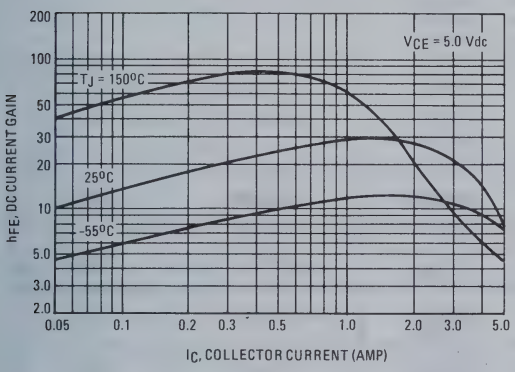


FIGURE 4 – "ON" VOLTAGES

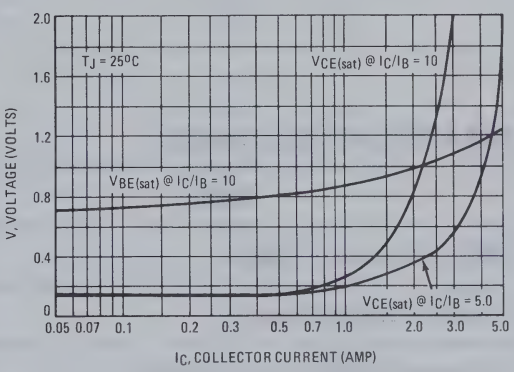
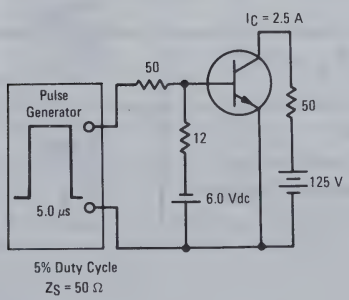


FIGURE 5 – SWITCHING CIRCUIT



2N5265 thru 2N5270

(SILICON)



P-Channel junction depletion mode (Type A) field-effect transistors designed for general-purpose amplifier applications.

CASE 20(5)
(TO-72)

Style 5:
Pin 1. Source
2. Gate 1
3. Drain
4. Case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	60	Vdc
Drain Current	I_D	20	mAdc
Gate Current-forward	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	60	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	2N5265, 2N5266	$V_{GS(off)}$	-	3.0	Vdc
	2N5267, 2N5268		-	6.0	
	2N5269, 2N5270		-	8.0	
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 150°C)			-	2.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5265	I_{DSS}	0.5	1.0	mAdc
	2N5266		0.8	1.6	
	2N5267		1.5	3.0	
	2N5268		2.5	5.0	
	2N5269		4.0	8.0	
	2N5270		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.05 mAdc)	2N5265	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 0.08 mAdc)	2N5266		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 0.15 mAdc)	2N5267		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.25 mAdc)	2N5268		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	2N5269		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 0.7 mAdc)	2N5270		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5265	$\|y_{fs}\|$	900	2700	μmhos
	2N5266		1000	3000	
	2N5267		1500	3500	
	2N5268		2000	4000	
	2N5269		2200	4500	
	2N5270		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5265	$Re(y_{fs})$	800	-	μmhos
	2N5266		900	-	
	2N5267		1400	-	
	2N5268		1700	-	
	2N5269		1900	-	
	2N5270		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

FIGURE 1–6 TRANSFER CHARACTERISTIC CURVES
FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

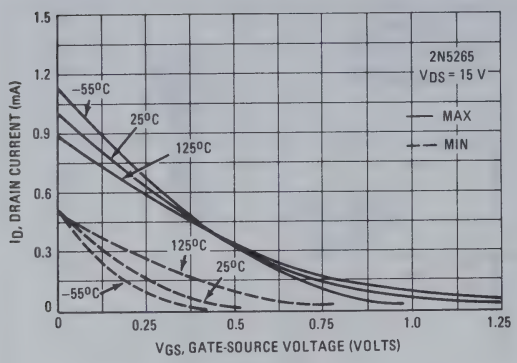


FIGURE 2

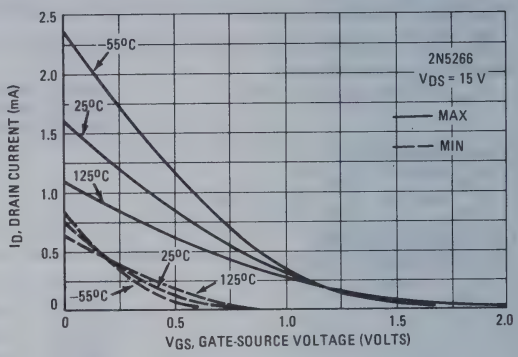


FIGURE 3

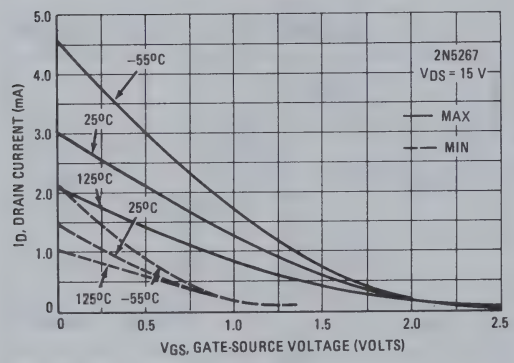


FIGURE 4

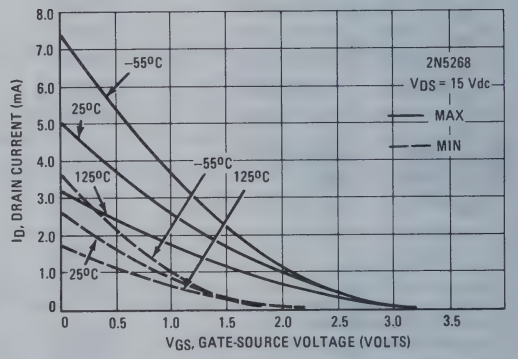


FIGURE 5

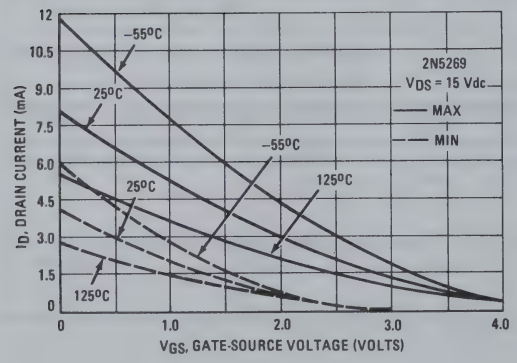
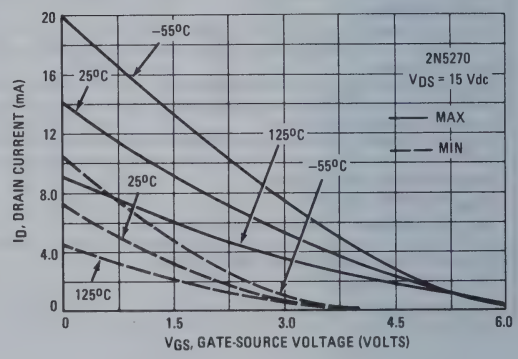


FIGURE 6



FIGURES 7-12 – TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

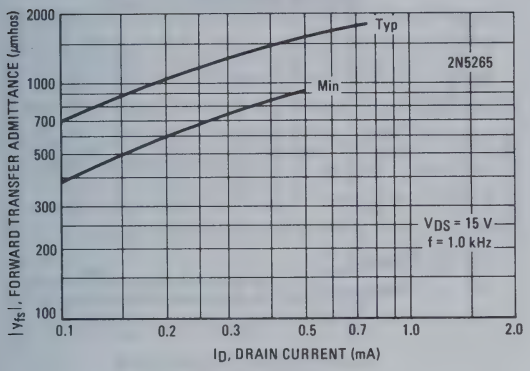


FIGURE 8

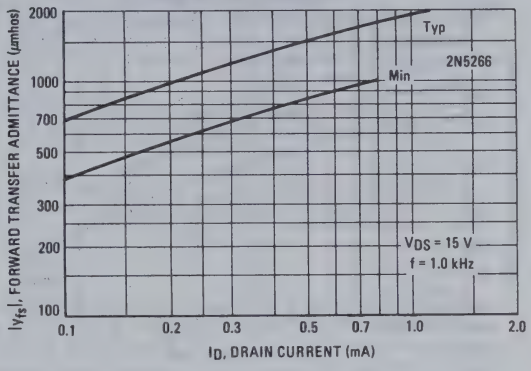


FIGURE 9

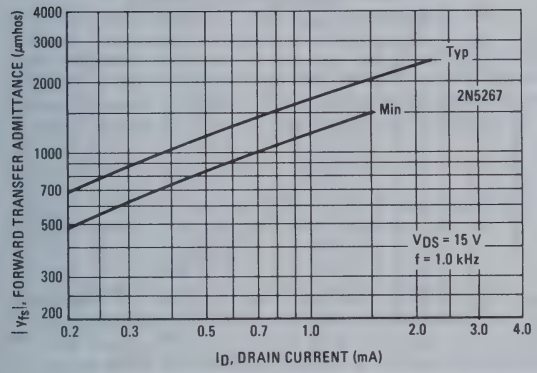


FIGURE 10

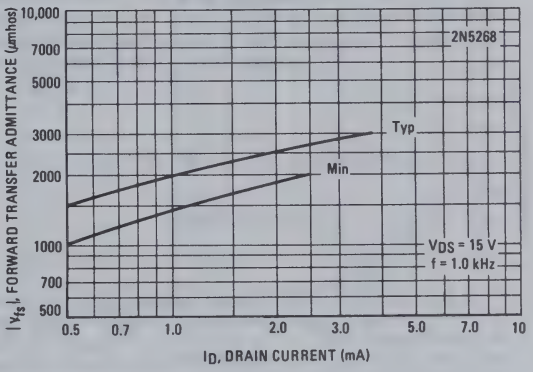


FIGURE 11

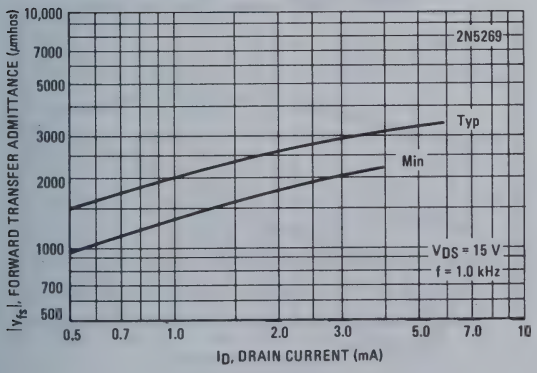
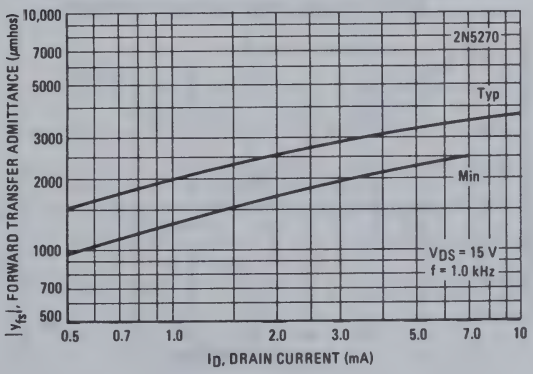


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

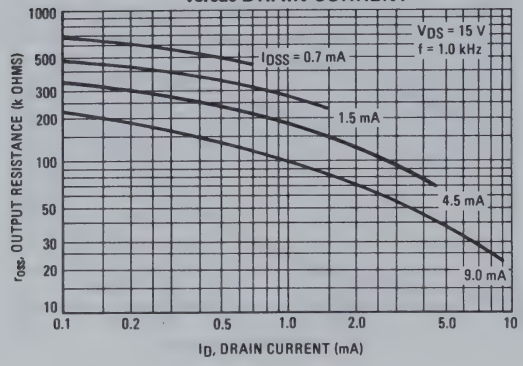


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

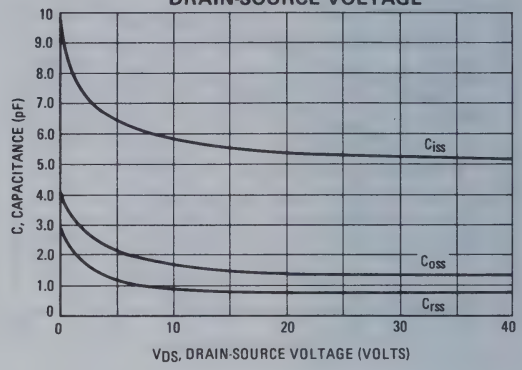


FIGURE 15 – NOISE FIGURE versus FREQUENCY

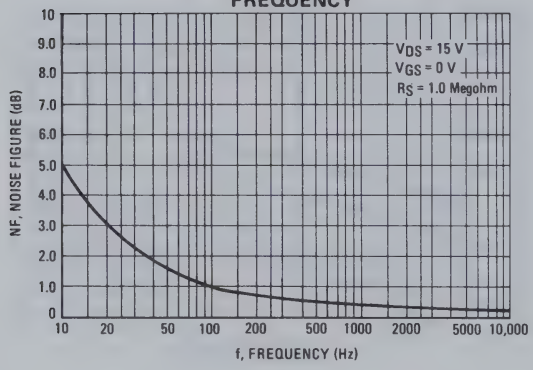


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

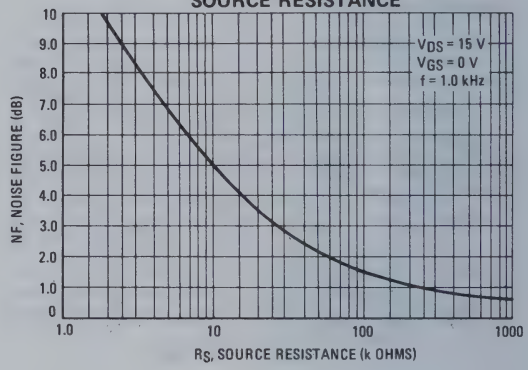


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

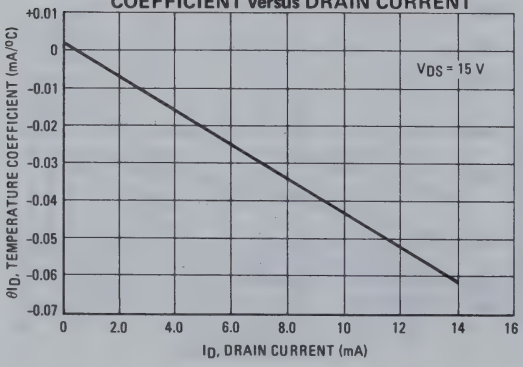


FIGURE 18 – FORWARD TRANSADMITTANCE COEFFICIENT versus DRAIN CURRENT

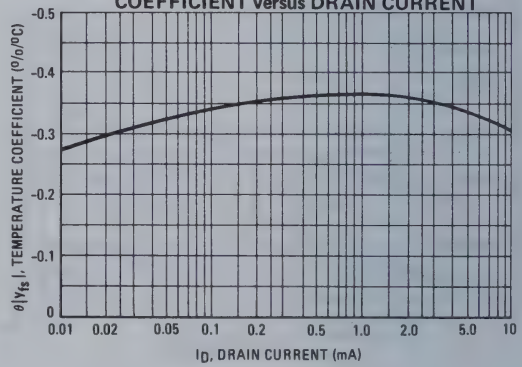
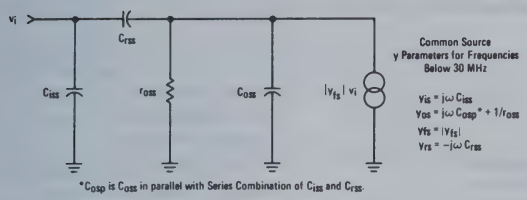


FIGURE 19 – EQUIVALENT LOW FREQUENCY CIRCUIT



*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9\ Vdc - 0.8\ Vdc}{(1.25\ mA - 0.75\ mA)} = 2.2\ k\ Ohms$$

$$V_G = \frac{I_{D(max)}\ V_{GS(min)} - I_{D(min)}\ V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \times 0.80 - 0.75 \times 1.9}{0.5} = -0.9\ Vdc$$

BIAS NETWORK DESIGN FOR WORST CASE I_{DSS} VARIANCE

This Designers Data Sheet has been published to assist the circuit designer in optimizing his "worst case" design. The following example illustrates the use of the forward transfer characteristics curves (Pigures 1 thru 6) in the design of a typical bias network.

Given: V_{DD} = -30 Vdc, I_D = 1.0 ± 0.25 mAdc from -55°C to +125°C

Procedure: The 2N5268 "worst case" bias conditions across the temperature range (from Figure 4) are reproduced in Figure A. The first step in the bias network design is to determine the value of the source resistance (R_S) necessary to hold the ± 0.25 mAdc I_D bias tolerance. To solve R_S, plot $I_{D(max)}$ and $I_{D(min)}$ on Figure A and calculate R_S, and V_G.

In Figure B the maximum allowable value for R_1 will be determined by loading due to gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, we can assume that it will double with each 15°C temperature rise. Therefore, we can assume a maximum reverse current of approximately 0.5 μAdc at 125°C, based on the specified maximum 2.0 μAdc reverse at 150°C. The variation in V_G bias versus temperature will not be too great if we chose a value for R_1 which results in a bias network current (I_1 in Figure B) greater than 5 times the maximum reverse current. Assuming a value for R_1 of 9.1 Megohms, R_2 can be solved from the equation:

$$V_G = -0.9\ Vdc \approx \frac{-30\ R_2}{9.1 + R_2}\ (Ignoring\ I_G)$$

$$R_2 \approx 300\ k\ Ohms$$

Using the above values of R_1 and R_2, the variation in V_G can be computed for I_G = 0 to I_G = 0.5 μAdc. V_G will vary from 0.81 Vdc at I_G = 0.5 μAdc to 0.96 Vdc @ I_G = 0. This variation will have a minimal effect on I_D, as can be seen from Figure A by plotting load lines with a slope equal to $1/R_S$ from V_G = 0.81 Vdc and 0.96 Vdc respectively.

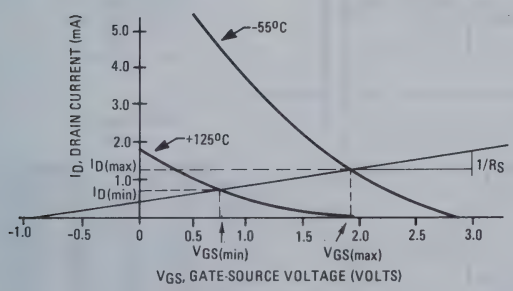


FIGURE A

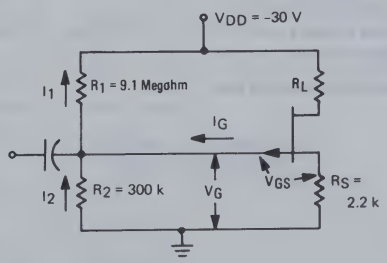


FIGURE B

2N5271 (SILICON)

NPN SILICON ANNULAR AVALANCHE TRANSISTOR

. . . designed for AVALANCHE mode operation for the generation of high-current pulses with nanosecond rise times. Ideal for applications such as laser diodes, high-current pulse generators, vacuum tube driver and other applications requiring ultra high-speed, high-voltage or high-current pulses.

- Rise Time – t_r = 1.0 ns (Max)
- Delay Time – t_d = 5.0 ns (Max)
- Output Pulse Amplitude – V_o = 130 Vdc (Typ) @ R_L = 50 Ohms

NPN SILICON AVALANCHE SWITCHING TRANSISTOR

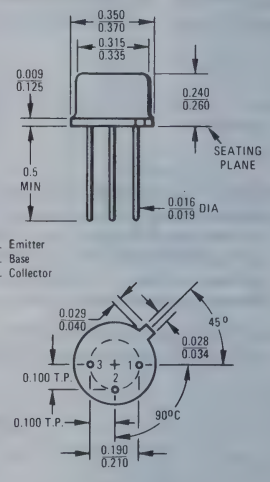
$t_r < 1.0$ ns



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Peak	I_C	5.0	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	600 3.43	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data



CASE 79-02
TO-39

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.890	9.400	0.350	0.370
B	8.000	8.510	0.315	0.335
C	6.100	6.600	0.240	0.260
D	0.406	0.483	0.016	0.019
E	0.229	3.180	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.830	5.330	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.020	0.029	0.040
K	12.700	–	0.500	–
L	2.540 TP		0.100 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

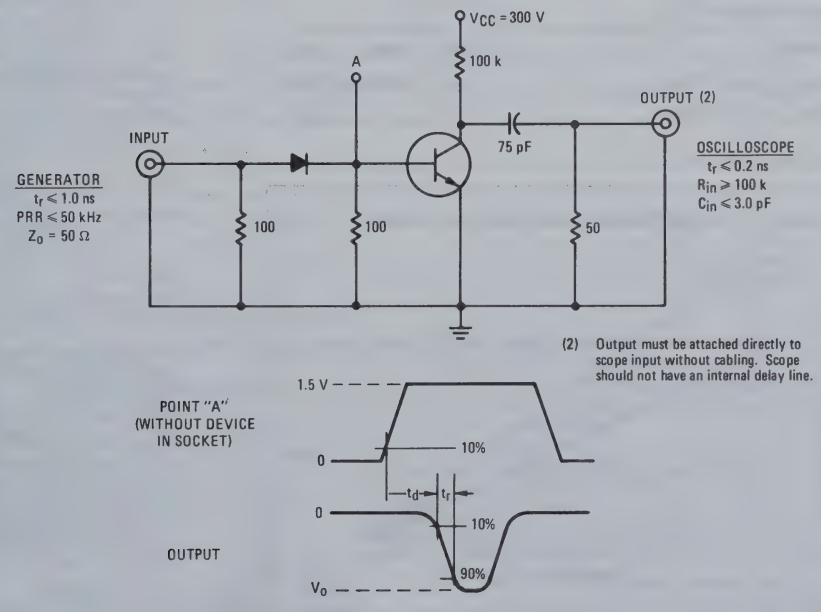
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, R_{BE} = 100 Ohms)	BV_{CER}	200	–	280	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 160 Vdc, R_{BE} = 100 Ohms)	I_{CER}	–	–	20	nAdc
Collector Holdoff Current(1) (R_{BE} = 100 Ohms, T_A = +55°C)	$I_{CER(H)}$	0.5	–	–	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
DYNAMIC CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	C_{cb}	–	–	6.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{eb}	–	–	16	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Delay Time	t_d	–	–	5.0	ns
Rise Time	t_r	–	–	1.0	ns
Output Pulse Amplitude (Figure 1)	V_o	100	130	–	Vdc

*Indicates JEDEC Registered Data.

(1) Collector Holdoff Current is that value of collector cutoff current above which the reverse voltage-current characteristic exhibits negative resistance.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



2N5301 (SILICON)
2N5302
2N5303

HIGH-POWER NPN SILICON TRANSISTORS

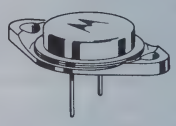
. . . for use in power amplifier and switching circuits applications.

- High Collector-Emitter Sustaining Voltage –
  $BV_{CEO(sus)}$ = 80 Vdc (Min) @ I_C = 200 mAdc (2N5303)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 10 Adc (2N5301, 2N5302)
  1.0 Vdc (Max) @ I_C = 10 Adc (2N5303)
- Excellent Safe Operating Area –
  200 Watt dc Power Rating to 30 Vdc (2N5303)
- Complements to PNP 2N4398, 2N4399 and 2N5745

20 AND 30 AMPERE POWER TRANSISTORS

NPN SILICON

40–60–80 VOLTS
200 WATTS



*MAXIMUM RATINGS

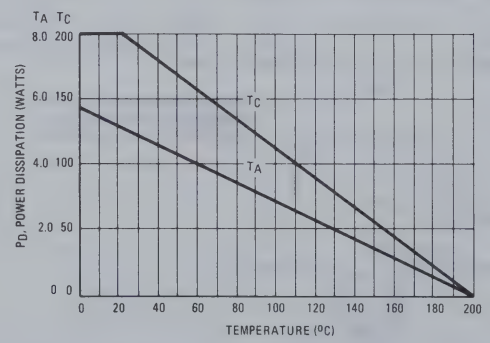
Rating	Symbol	2N5301	2N5302	2N5303	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Collector Current – Continuous	I_C	30	30	20	Adc
Base Current	I_B	← 7.5 →			Adc
Total Device Dissipation @ T_C=25°C Derate above 25°C	P_D	← 200 → ← 1.14 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← -65 to +200 →			°C

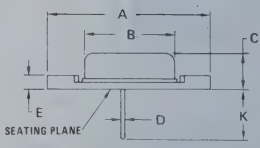
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	34	°C/W

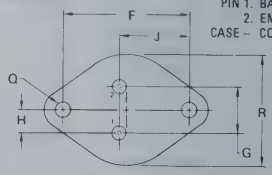
*Indicates JEDEC Registered Data.

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE – COLLECTOR



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 12-01

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5301		40	–	
	2N5302		60	–	
	2N5303		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5301		–	5.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5302		–	5.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5303		–	5.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5301		–	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5302		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5303		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5301		–	10	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5302		–	10	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5303		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5301		–	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N5302		–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5303		–	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
*(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	ALL TYPES		40	–	
*(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		15	60	
*(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		15	60	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		5.0	–	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		5.0	–	
*Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5301,2N5302		–	0.75	
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5303		–	1.0	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	1.5	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.0	
(I_C = 30 Adc, I_B = 6.0 Adc)	2N5301,2N5302		–	3.0	
*Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	ALL TYPES		–	1.7	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5301,2N5302		–	1.8	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	2.0	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.5	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.5	
*Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$			Vdc
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		–	1.5	
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		–	1.7	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		–	2.5	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		–	3.0	
***DYNAMIC CHARACTERISTICS**					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–
***SWITCHING CHARACTERISTICS**					
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	t_r	–	1.0	μs
Storage Time		t_s	–	2.0	μs
Fall Time		t_f	–	1.0	μs

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 – TURN-ON TIME

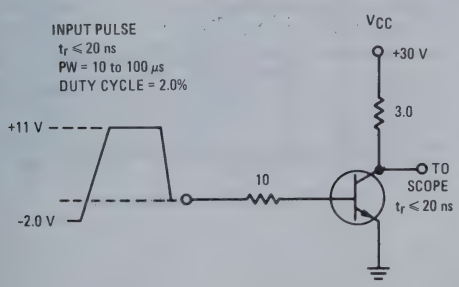
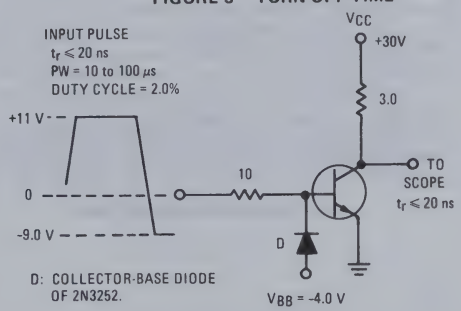


FIGURE 3 – TURN-OFF TIME



D: COLLECTOR-BASE DIODE OF 2N3252.

FIGURE 4 – THERMAL RESPONSE

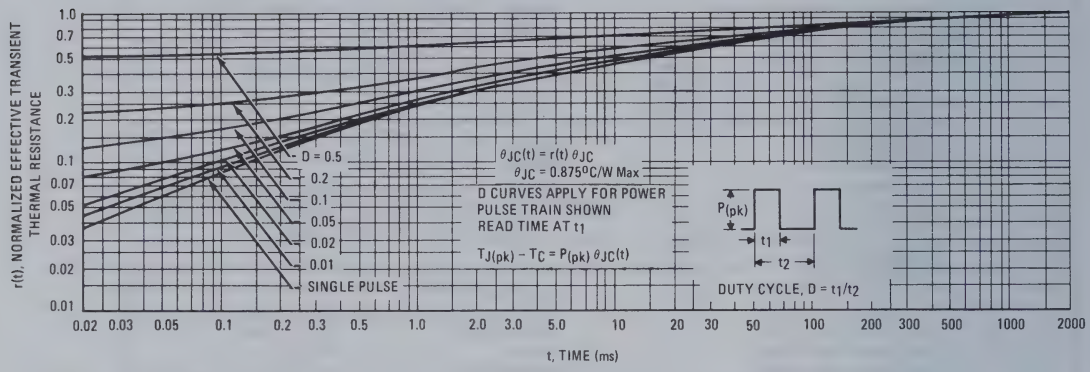


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA

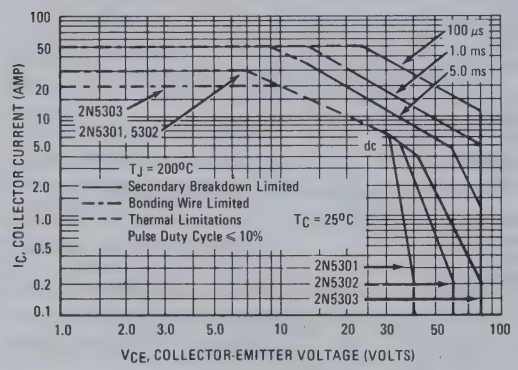


FIGURE 6 – CAPACITANCE versus VOLTAGE

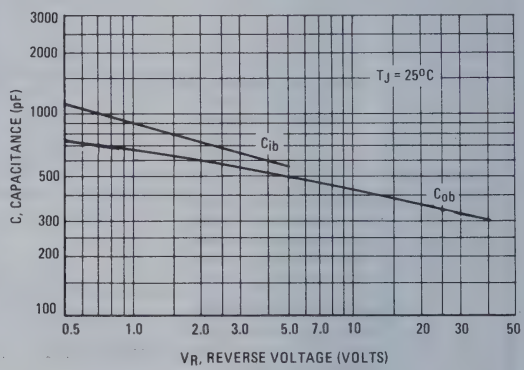


FIGURE 7 – TURN-ON TIME

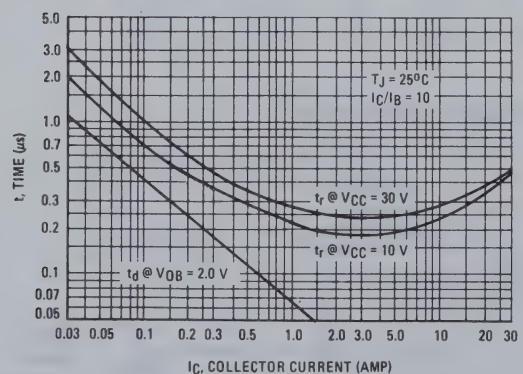


FIGURE 8 – TURN-OFF TIME

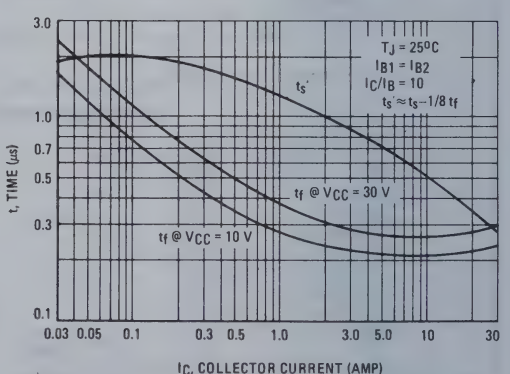


FIGURE 9 – DC CURRENT GAIN

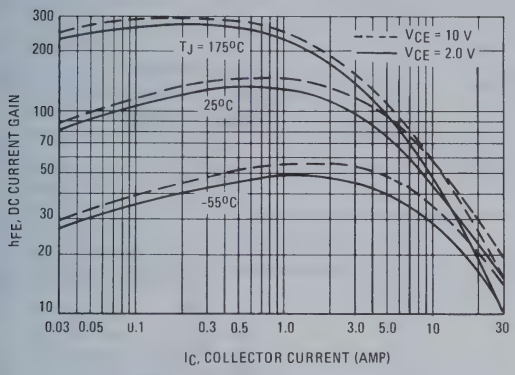


FIGURE 10 – COLLECTOR SATURATION REGION

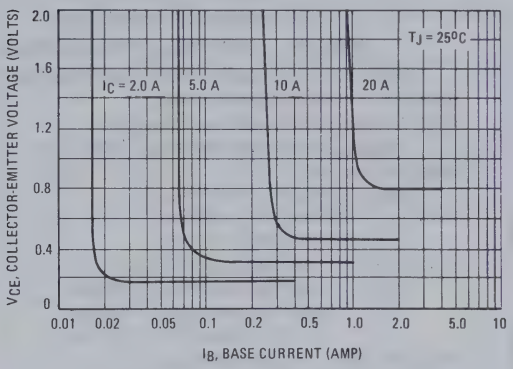


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

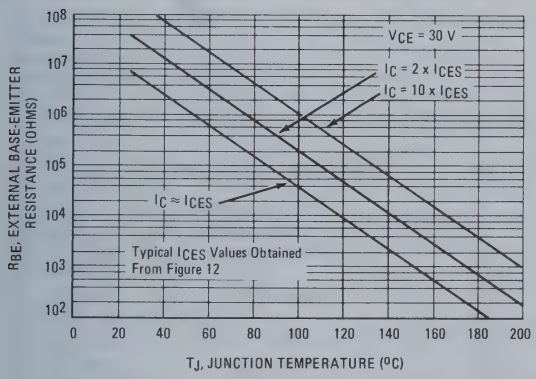


FIGURE 12 – "ON" VOLTAGES

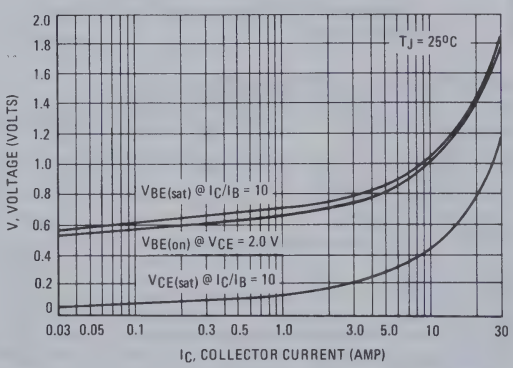


FIGURE 13 – COLLECTOR CUT-OFF REGION

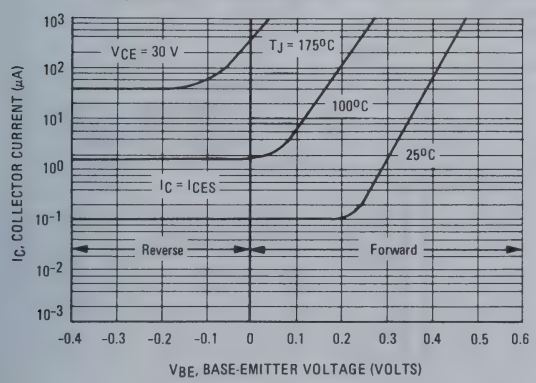
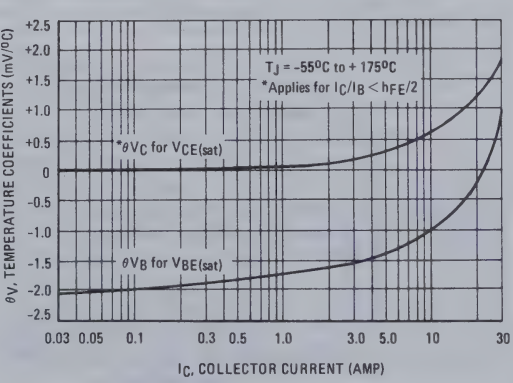


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N5304 (SILICON)

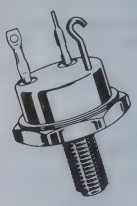
RADIATION-RESISTANT NPN SILICON POWER TRANSISTOR

. . . designed for high-speed switching and wide-band amplifier applications in radiation environments.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40 Vdc (Min) @ I_C = 100 mAdc
- DC Current Gain —
  h_{FE} = 30-120 @ I_C = 2.0 Adc
  = 25 (Min) @ I_C = 5.0 Adc
  = 12 (Min) @ I_C = 10 Adc
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 2.0 Adc
  = 0.8 Vdc (Max) @ I_C = 5.0 Adc
  = 1.2 Vdc (Max) @ I_C = 10 Adc
- Current-Gain — Bandwidth Product—
  f_T = 100 MHz (Min) @ I_C = 0.5 Adc
- Collector Cutoff Current, DC Current Gain and Collector-Emitter Saturation Voltage Limits Guaranteed After Exposure to 1 x 10^{14} Fast Neutron/cm^2.

10 AMPERE POWER TRANSISTOR NPN SILICON

40 VOLTS
25 WATTS



GUARANTEED RADIATION RESISTANCE CAPABILITIES

After 1 x 10^{14} n/cm^2 Fast Neutron (E > 10 keV) Exposure (Fission Spectrum)

Characteristic	Symbol	Min	Max	Unit
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	5.0	–	–
Collector Cutoff Current (V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc	I_{CEX}	–	50	μAdc
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$	–	1.5	Vdc

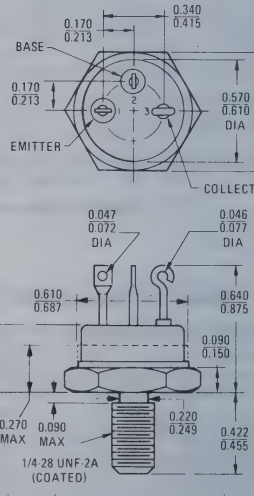
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	10	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 125°C Derate above 125°C	P_D	25 0.333	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C
Fast Neutron Radiation Level	–	1x10^{14}	n/cm^2

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	°C/W

*Indicates JEDEC Registered Data

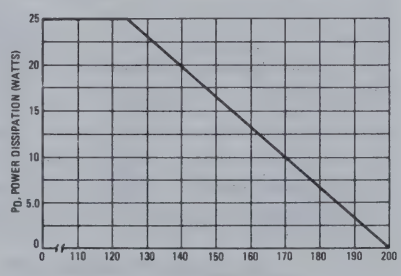


All JEDEC dimensions and notes apply

Collector connected to case

CASE 9
TO-61

FIGURE 1 – POWER DERATING



***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	–	200	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	10	μAdc
(V_{CE} = 25 Vdc, $V_{EB(off)}$ = 1.5 Vdc T_C = 150°C)		–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	25	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		30	120	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		25	–	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)		12	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		–	0.4	
(I_C = 5.0 Adc, I_B = 500 mAdc)		–	0.8	
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)		–	1.2	
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.8	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	300	pF
SWITCHING CHARACTERISTICS				
Rise Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_r	–	100	ns
Storage Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc, I_{B2} = 100 mAdc)	t_s	–	700	ns
Fall Time (V_{CC} ≈ 20 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc, I_{B2} = 100 mAdc)	t_f	–	100	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle≈2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

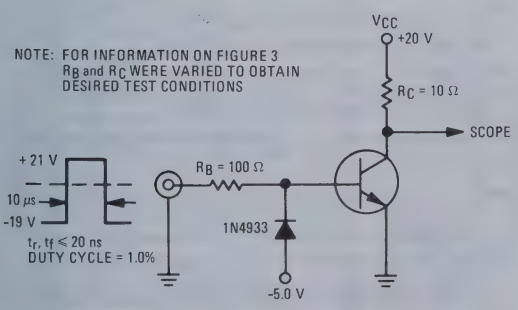


FIGURE 3 – SWITCHING TIMES

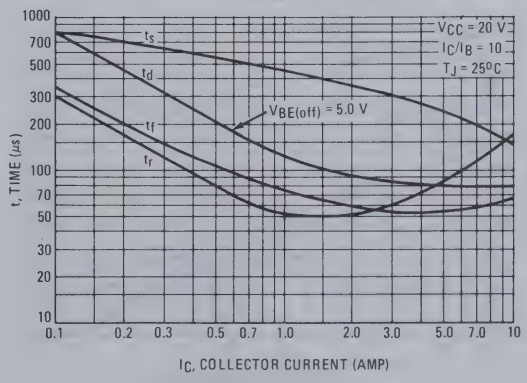


FIGURE 4 – THERMAL RESPONSE

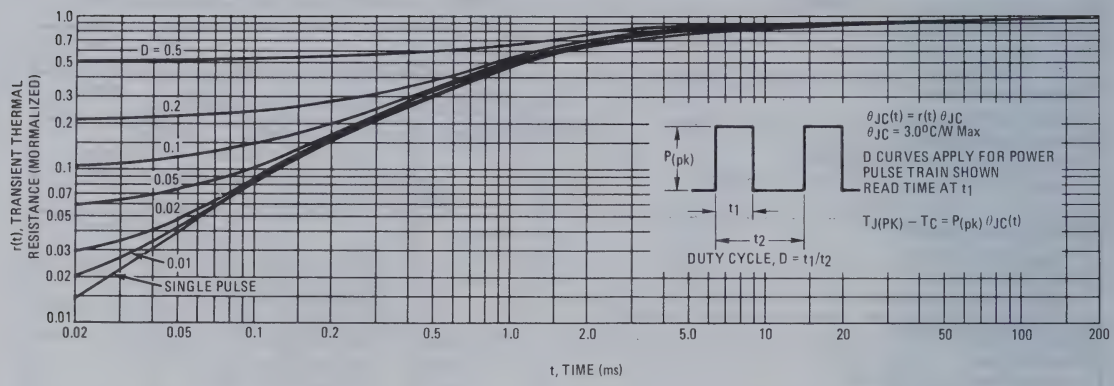
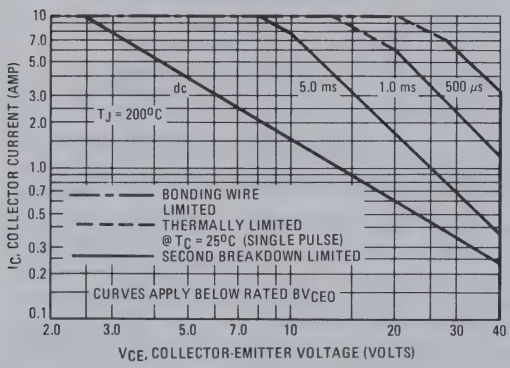
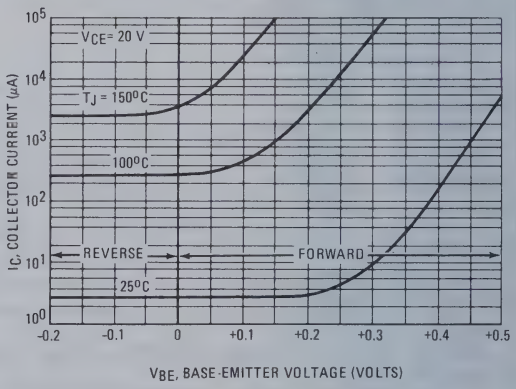


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

FIGURE 6 – COLLECTOR CUTOFF REGION



The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 7 – CAPACITANCE

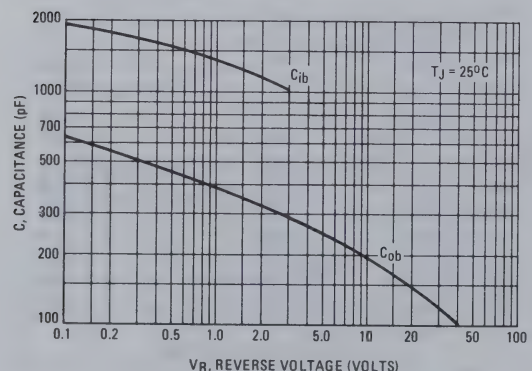


FIGURE 8 – BASE CUTOFF REGION

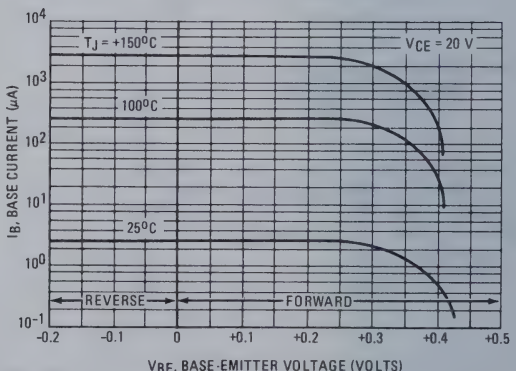


FIGURE 9 – DC CURRENT GAIN

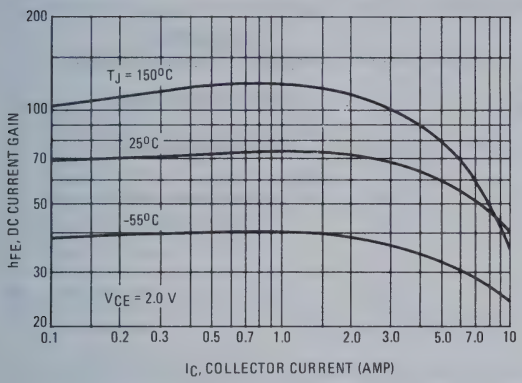


FIGURE 10 – COLLECTOR SATURATION REGION

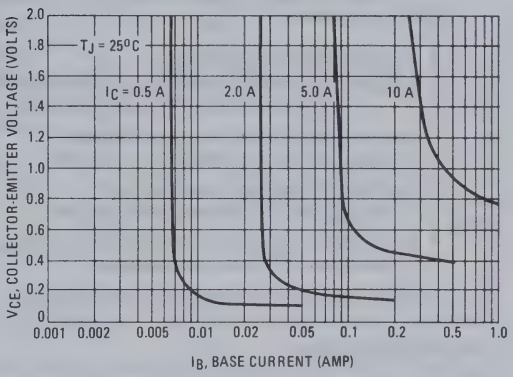


FIGURE 11 – "ON" VOLTAGES

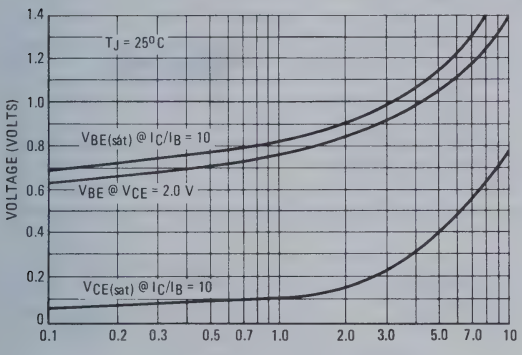
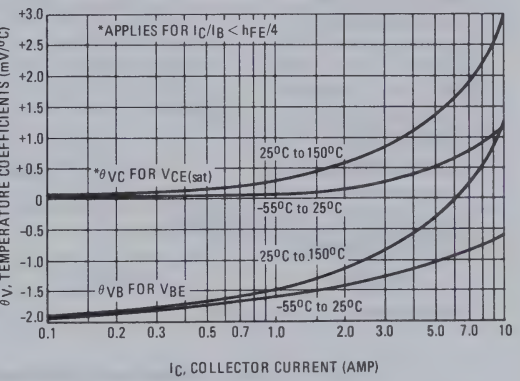


FIGURE 12 – TEMPERATURE COEFFICIENTS



EFFECTS OF FAST NEUTRON DOSAGE

FIGURE 13 – DC CURRENT GAIN

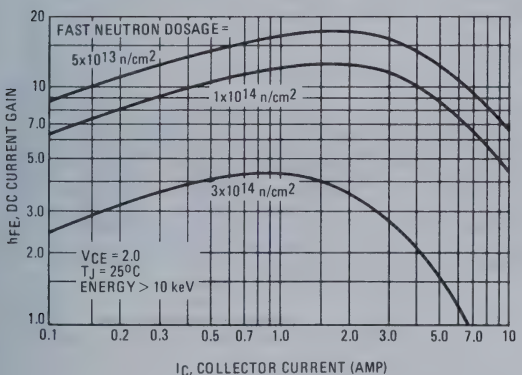
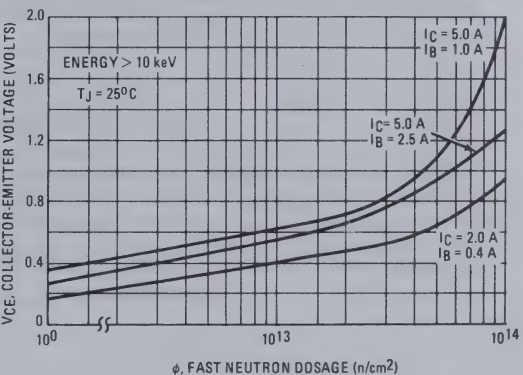


FIGURE 14 – COLLECTOR-EMITTER SATURATION VOLTAGE



2N5324 (GERMANIUM)
2N5325

PNP GERMANIUM POWER TRANSISTORS

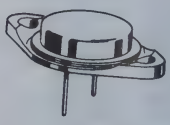
. . . designed primarily for switching, inverter, and industrial power supply applications.

- Low Collector Cutoff Current –
  I_{CEX} = 7.0 mAdc (Max) @ V_{CEX} = 250 Vdc (2N5324)
  7.0 mAdc (Max) @ V_{CEX} = 325 Vdc (2N5325)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 10 Adc
- Low Base-Emitter Saturation Voltage –
  $V_{BE(sat)}$ = 0.75 Vdc (Max) @ I_C = 10 Adc
- Guaranteed Excellent Safe Operating Area ($V_{CER(sus)}$)
  Specified at 3.0 Amps and 10 Amps
- 100% Stabilization Bake at 125°C for 100 Hours

10 AMPERE
POWER TRANSISTORS
PNP GERMANIUM
EPITAXIAL BASE
250-325 VOLTS
56 WATTS

*MAXIMUM RATINGS

Rating	Symbol	2N5324	2N5325	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current – Continuous	I_B	3.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	56 0.67		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110		°C

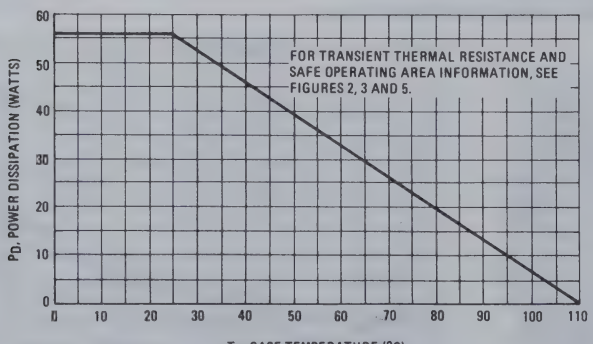


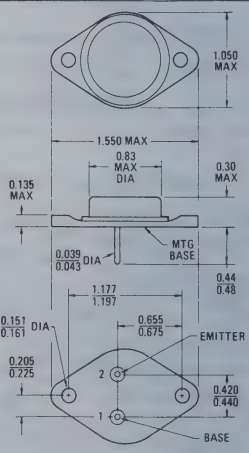
*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 11
TO-3
Collector Connected to case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
†Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5324	BV_{CEO}	150	–	Vdc
	2N5325		200	–	
Collector-Emitter Sustaining Voltage (I_C = 3.0 Adc, R_{BE} = 10 Ohms) (Figure 4, Test Condition 1)	2N5324	$V_{CER(sus)}$	165	–	Vdc
	2N5325		200	–	
(I_C = 10 Adc, R_{BE} = 10 Ohms) (Figure 4, Test Condition 2)	2N5324		100	–	
	2N5325		115	–	
*Collector Cutoff Current (See Note 1) (V_{CE} = 250 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5324	I_{CEV}	–	7.0	mAdc
(V_{CE} = 250 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)			–	35	
(V_{CE} = 325 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5325		–	7.0	
(V_{CE} = 325 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)			–	35	
*Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	60	–
*Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	–	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	–	0.75	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc, f = 0.5 MHz)		f_T	2.0	–	MHz
SWITCHING CHARACTERISTICS					
*Rise Time	(I_C = 5.0 Adc, I_{B1} = I_{B2} = 0.5 Adc) (See Figure 6)	t_r	–	15	μs
*Storage Time		t_s	–	10	μs
*Fall Time		t_f	–	7.0	μs

Note 1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

†JEDEC Registration Defined as $V_{(BR)CEO}$

FIGURE 2 – TRANSIENT THERMAL RESPONSE

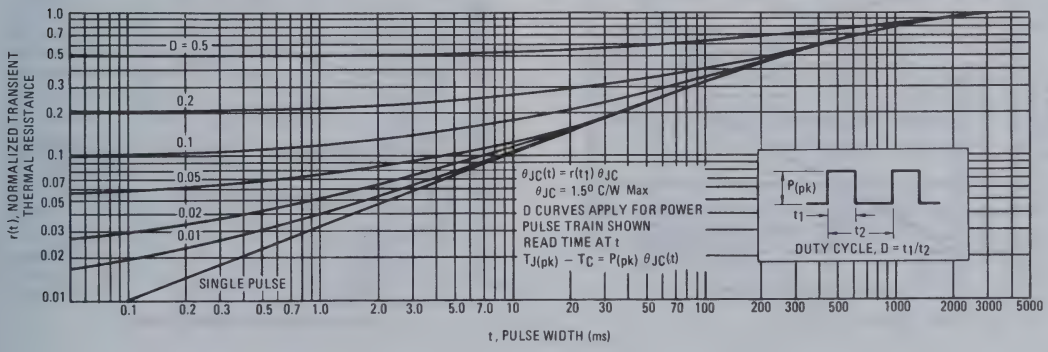


FIGURE 3 – COLLECTOR-EMITTER SUSTAINING VOLTAGE

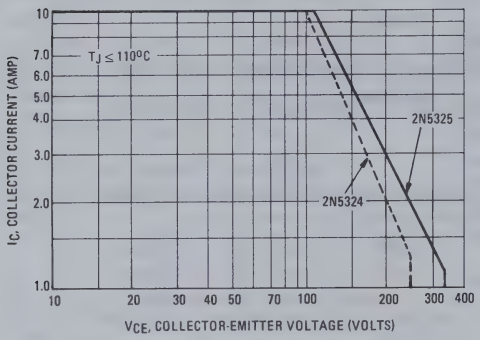


FIGURE 4 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUIT

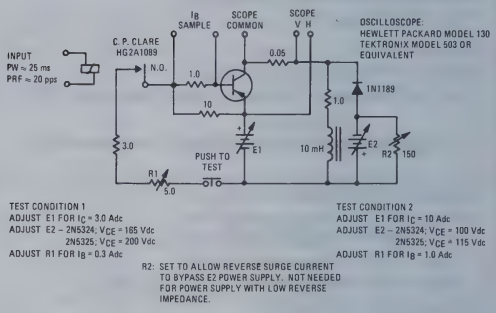


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

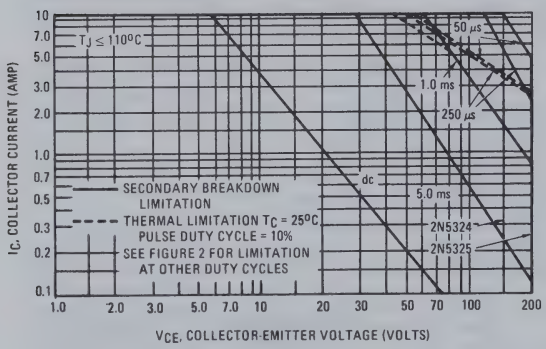


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

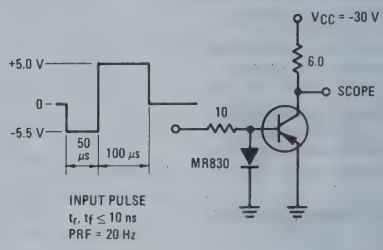


FIGURE 7 – SWITCHING TIMES

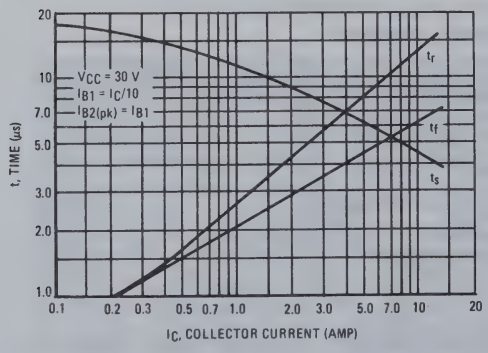


FIGURE 8 - CURRENT GAIN BANDWITH PRODUCT

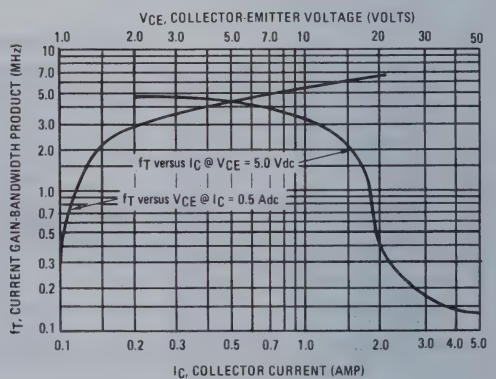


FIGURE 9 – DC CURRENT GAIN

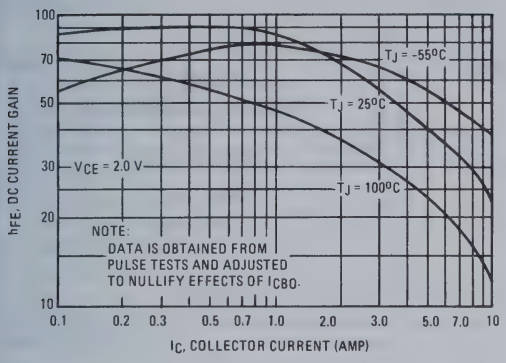


FIGURE 10 – COLLECTOR SATURATION REGION

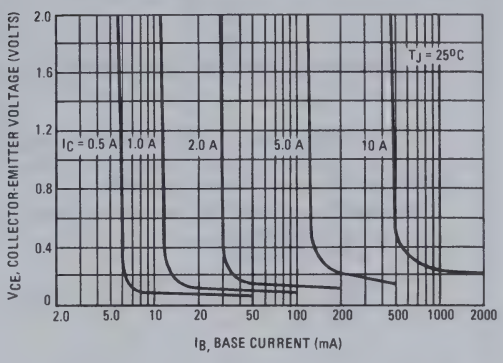


FIGURE 11 – EFFECTS OF EMITTER-BASE RESISTANCE

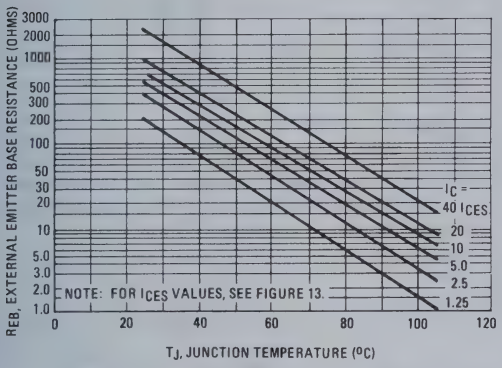


FIGURE 12 – "ON" VOLTAGES

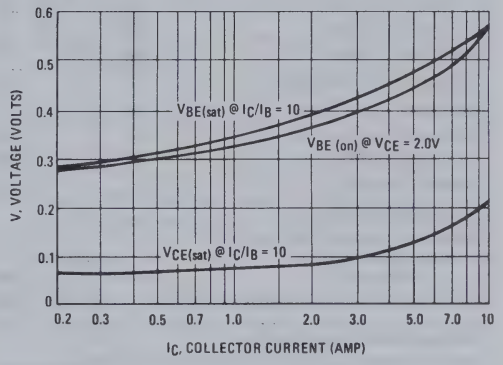


FIGURE 13 – COLLECTOR CUTOFF REGION

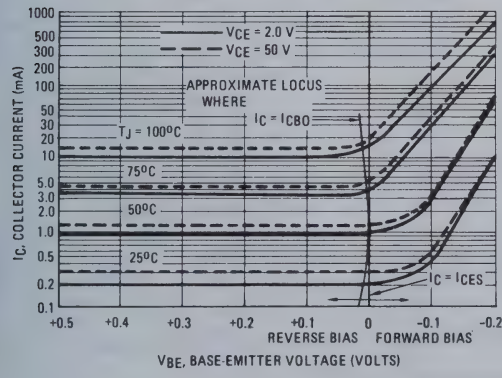
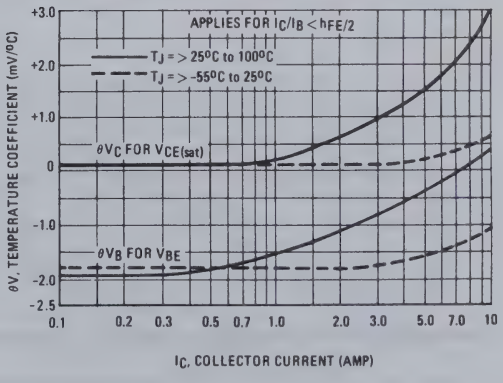


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N5334 (SILICON)
2N5335

HIGH-SPEED NPN SILICON POWER TRANSISTORS

. . . designed for fast switching and amplifier applications.

- Total Switching Time — 1.15 μs Max
- High Current Switching Specified at 1.0 Adc —
  t_{on} = 100 ns Max
  t_{off} = 1.05 μs Max
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 2.0 Adc

3 AMPERE
POWER TRANSISTORS

NPN SILICON

60-80 VOLTS
6 WATTS



*MAXIMUM RATINGS

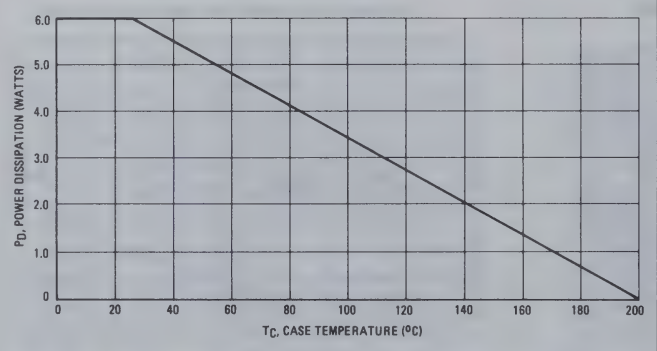
Rating	Symbol	2N5334	2N5335	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Collector Current - Continuous	I_C	3.0		Adc
Base Current - Continuous	I_B	0.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.0 34		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS**

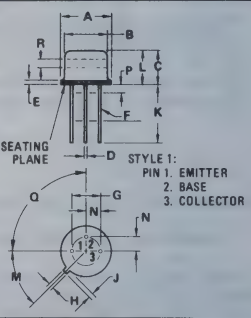
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29.1	°C/W

*Indicates JEDEC Registered Data.
**Motorola Guarantees this data in addition to JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

CASE 79-02
Note: All JEDEC notes and dimensions apply.
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N5334		60	–	
	2N5335		80	–	
**Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5334		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5335		–	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5334		–	500	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5335		–	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5334		–	5.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5335		–	5.0	
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{EB} = 8.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			30	150	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	0.7	
**(I_C = 3.0 Adc, I_B = 0.6 Adc)			–	1.8	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	1.5	Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)					
**Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$			Vdc
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			–	1.5	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			–	1.8	
*DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (Note 2)		f_T	40	–	MHz
(I_C = 0.1 Adc, V_{CE} = 10 Vdc, f = 10 MHz)					
Output Capacitance		C_{ob}	–	75	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)					
Input Capacitance		C_{ib}	–	250	pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)					
SWITCHING CHARACTERISTICS					
**Delay Time	(V_{CC} = 20 Vdc, $V_{EB(off)}$ = 3.7 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_d	–	50	ns
Rise Time		t_r	–	50	ns
Storage Time		t_s	–	950	ns
Fall Time		t_f	–	100	ns

*Indicates JEDEC Registered Data. **Motorola Guarantees this data in addition to JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

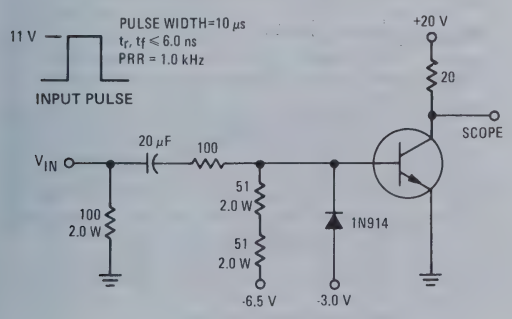


FIGURE 3 – TURN ON TIME

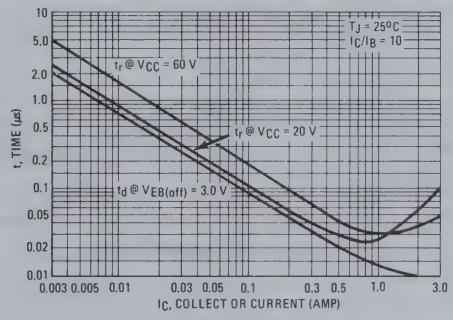


FIGURE 4 – THERMAL RESPONSE

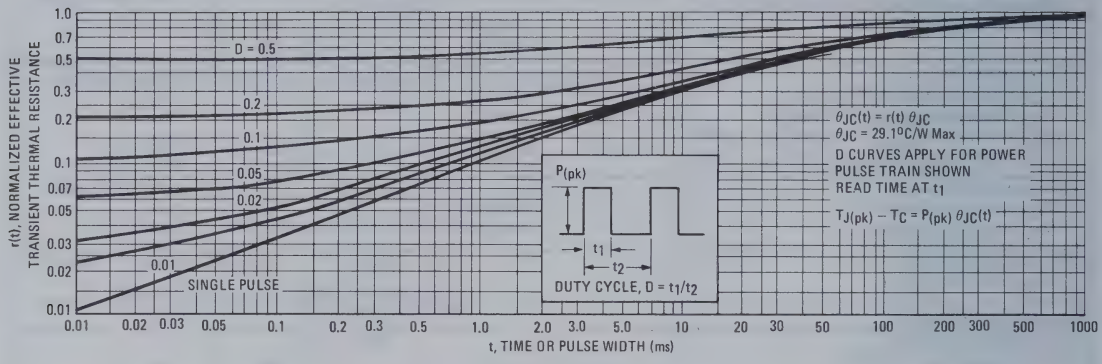
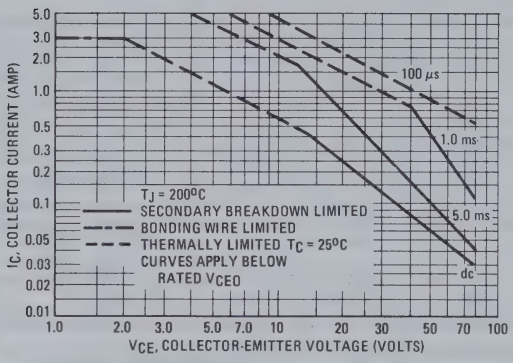


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C @ V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

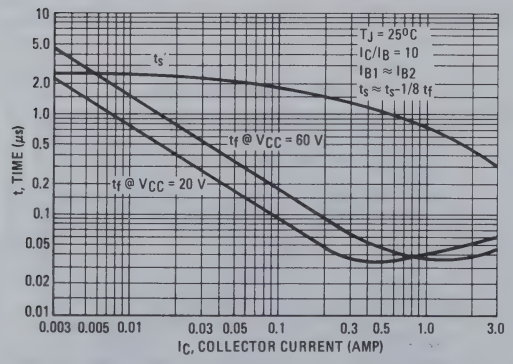
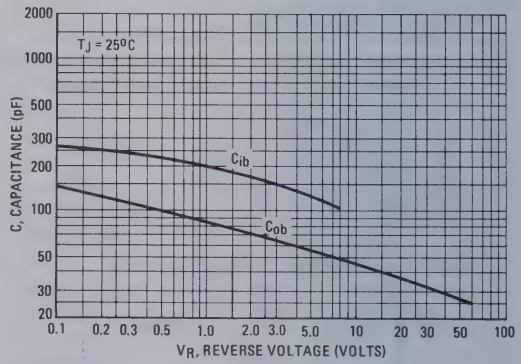


FIGURE 7 – CAPACITANCES



ELECTRICAL CHARACTERISTICS
(T_J = 25°C unless otherwise noted)

FIGURE 8 – CURRENT GAIN

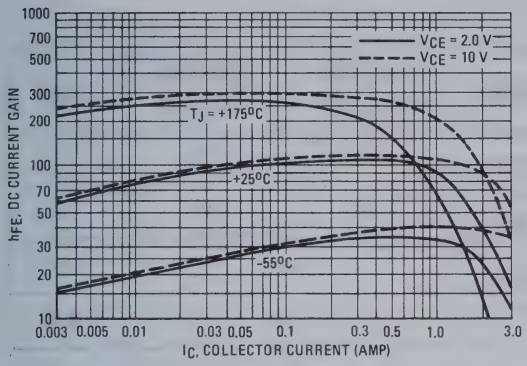


FIGURE 9 – COLLECTOR SATURATION REGION

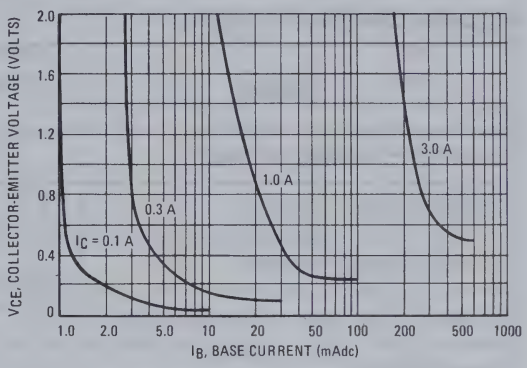


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

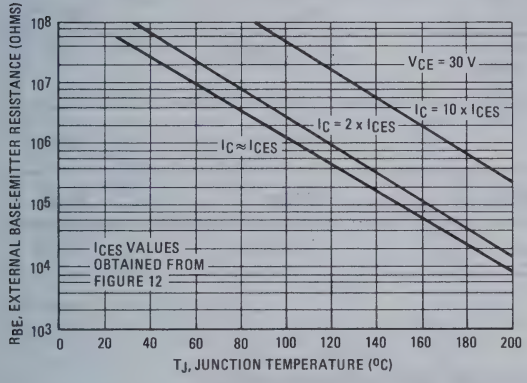


FIGURE 11 – "ON" VOLTAGES

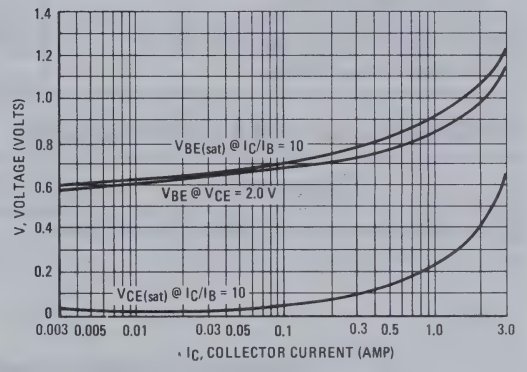


FIGURE 12 – COLLECTOR CUTOFF REGION

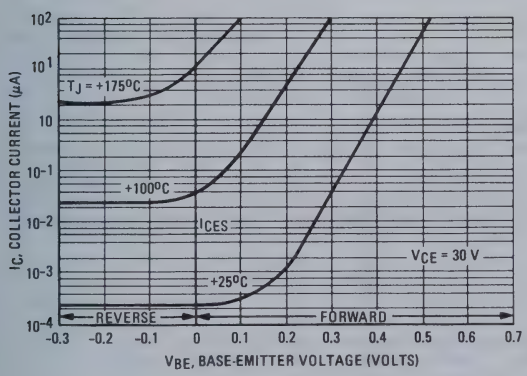
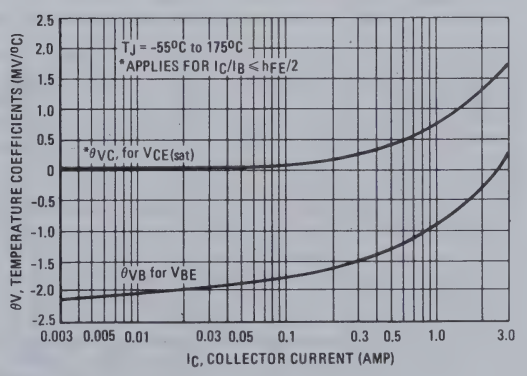


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5336 (SILICON) thru 2N5339



Medium-power NPN silicon transistors designed for switching and wide band amplifier applications.

CASE 79
(TO-39)

Style 1:
Pin 1. Emitter
2. Base
3. Collector

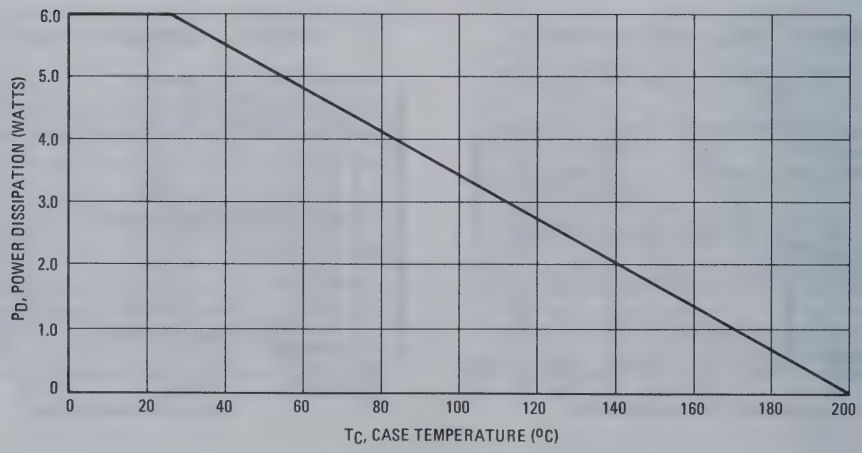
MAXIMUM RATINGS

Rating	Symbol	2N5336 2N5337	2N5338 2N5339	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.0 34.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29.2	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	2N5336, 2N5337	-	$BV_{CEO(sus)}$	80	-	Vdc
	2N5338, 2N5339			100	-	
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5336, 2N5337	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5338, 2N5339			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5336, 2N5337	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5338, 2N5339			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5336, 2N5337			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5338, 2N5339			-	1.0	
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	2N5336, 2N5337	-	I_{CBO}	-	10	μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5338, 2N5339			-	10	
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338	8	h_{FE}	30	-	-
	2N5337, 2N5339			60	-	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338			30	120	
	2N5337, 2N5339			60	240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338			20	-	
	2N5337, 2N5339			40	-	
Collector-Emitter Saturation Voltage (1) (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$	-	0.7	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)				-	1.2	
Base-Emitter Saturation Voltage (1) (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$	-	1.2	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)				-	1.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)		t_f	-	200	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

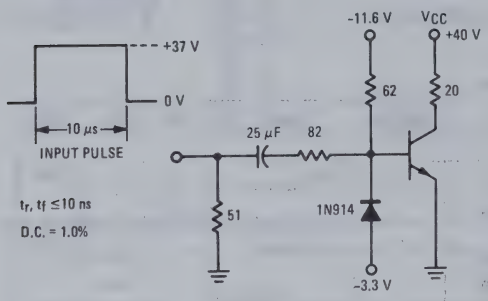


FIGURE 3 – TURN ON TIME

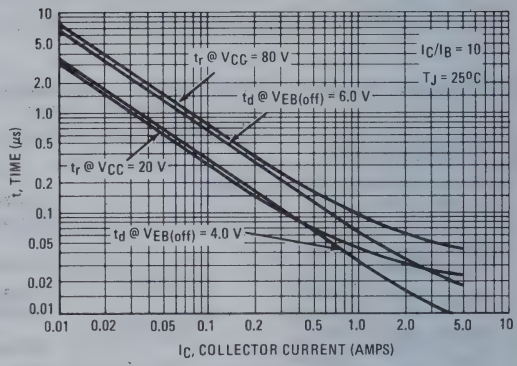


FIGURE 4 – THERMAL RESPONSE

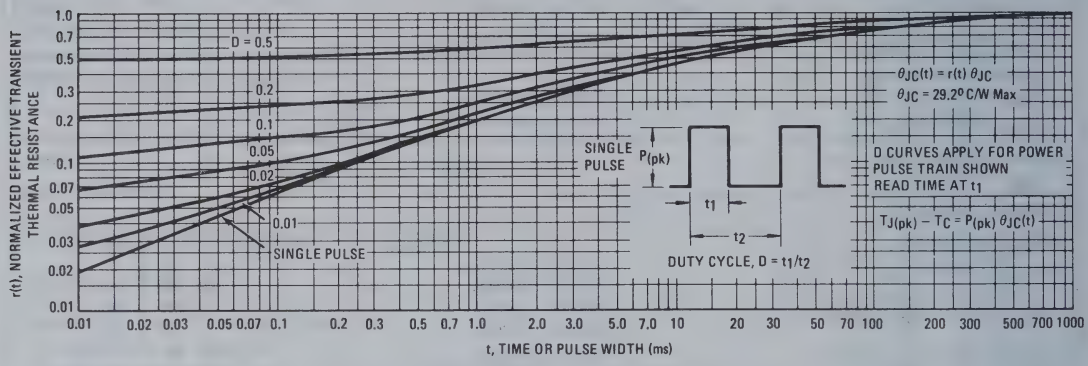
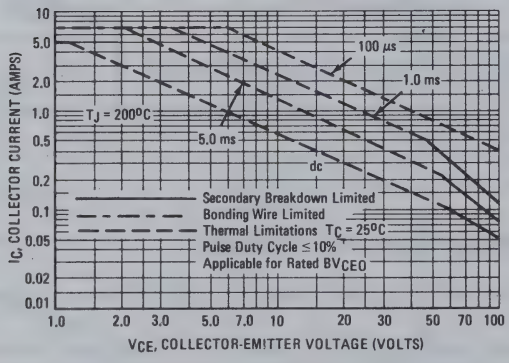


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

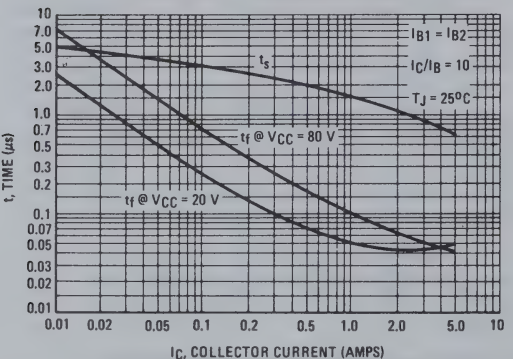


FIGURE 7 – CAPACITANCE versus VOLTAGE

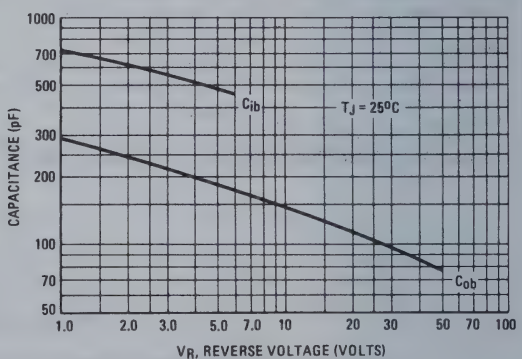


FIGURE 8 – DC CURRENT GAIN

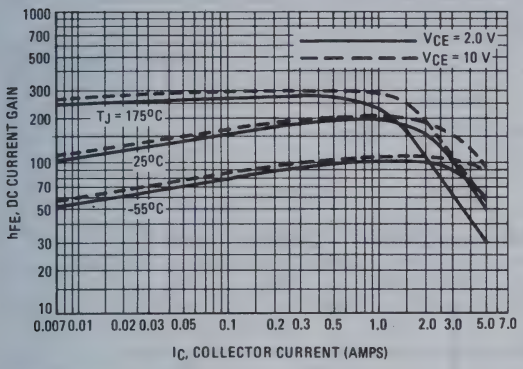


FIGURE 9 – COLLECTOR SATURATION REGION

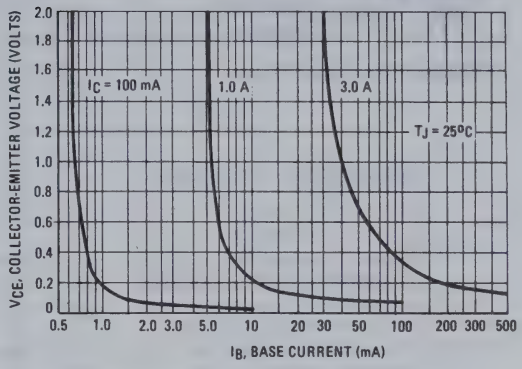


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

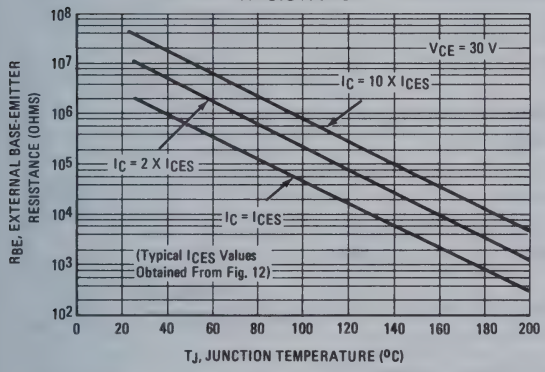


FIGURE 11 – ON VOLTAGES

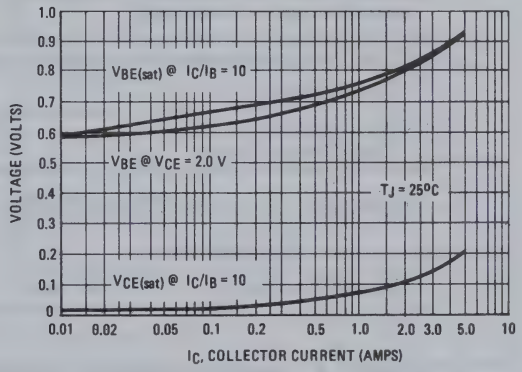


FIGURE 12 – COLLECTOR CUT-OFF REGION

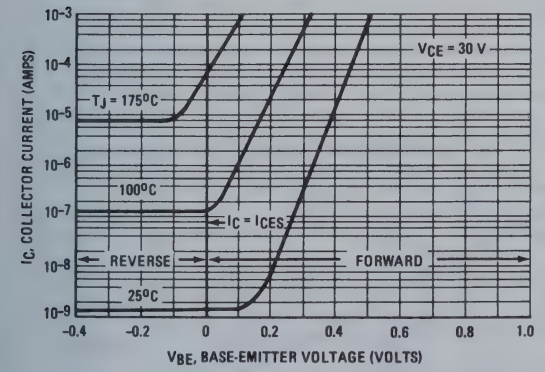
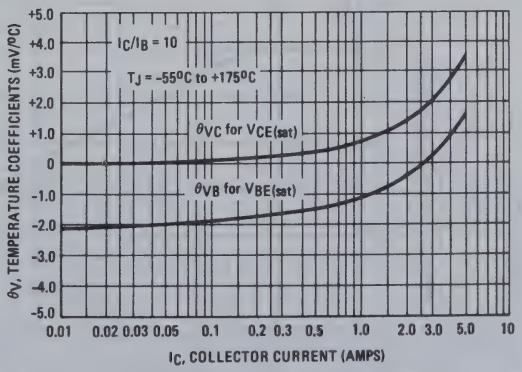
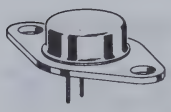


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5344 (SILICON)
2N5345

High voltage power PNP silicon transistors designed for high-voltage switching and amplifier applications.



CASE 80
(TO-66)

Collector connected to case

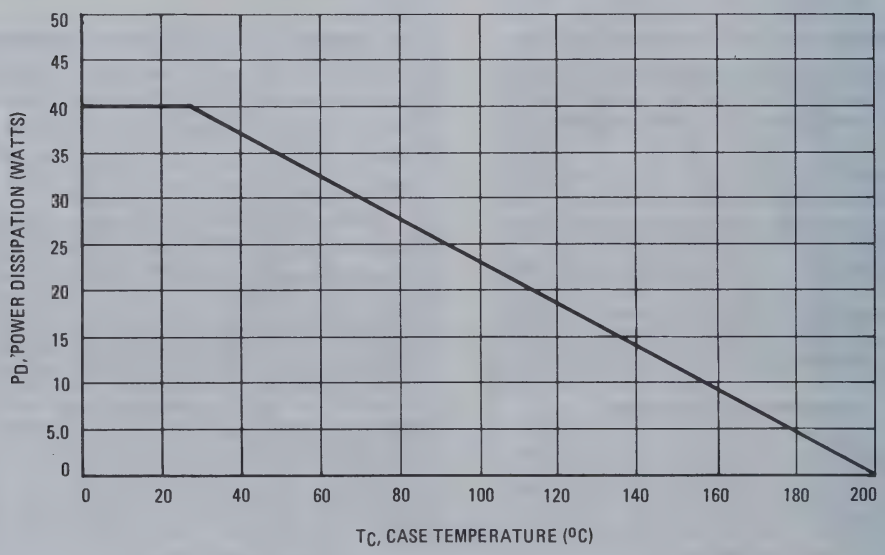
MAXIMUM RATINGS

Rating	Symbol	2N5344	2N5345	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	Vdc
Collector-Base Voltage	V_{CB}	250	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Base Current — Continuous	I_B	0.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 228		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.38	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves Are Indicated By Figure 5. All Limits Are Applicable And Must Be Observed

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0) 2N5344	5	$V_{CEO(sus)}$	250	-	Vdc
2N5345			300	-	
Collector Cutoff Current (V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc) 2N5344	10, 12	I_{CEX}	-	100	μAdc
(V_{CE} = 270 Vdc, $V_{BE(off)}$ = 1.5 Vdc) 2N5345			-	100	
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) 2N5344			-	1.0	mAdc
(V_{CE} = 270 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) 2N5345			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	8	h_{FE}	25	100	-
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			7.0	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.2 Adc)	9, 11, 13	$V_{CE(sat)}$	-	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.2 Adc)	11, 13	$V_{BE(sat)}$	-	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 10 MHz)	-	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	7	C_{ob}	-	200	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 0.85 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	2, 3	t_d	-	100	ns
Rise Time	2, 3	t_r	-	100	ns
Storage Time (V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	2, 6	t_s	-	600	ns
Fall Time	2, 6	t_f	-	100	ns

(1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

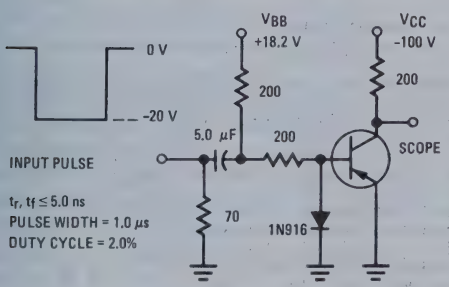


FIGURE 3 – TURN-ON TIME

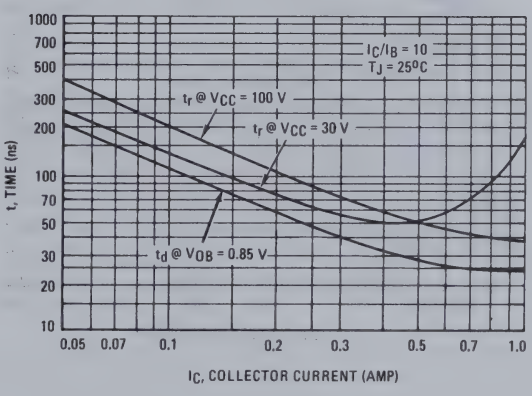


FIGURE 4 – THERMAL RESPONSE

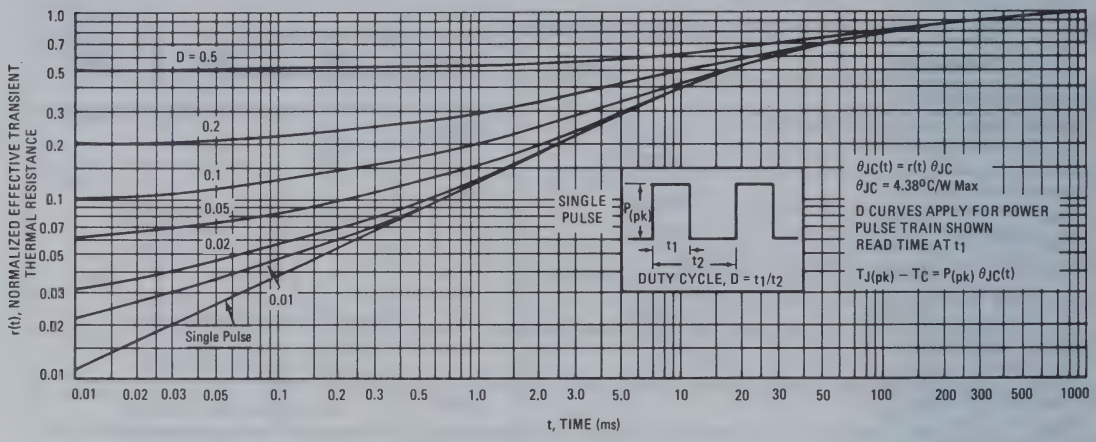
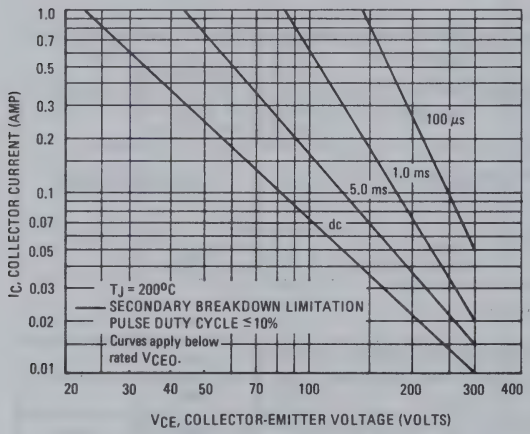


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

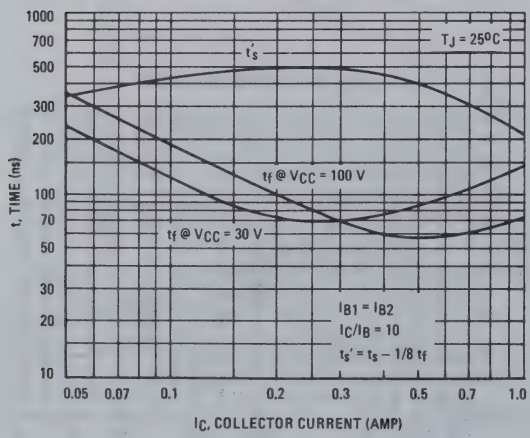
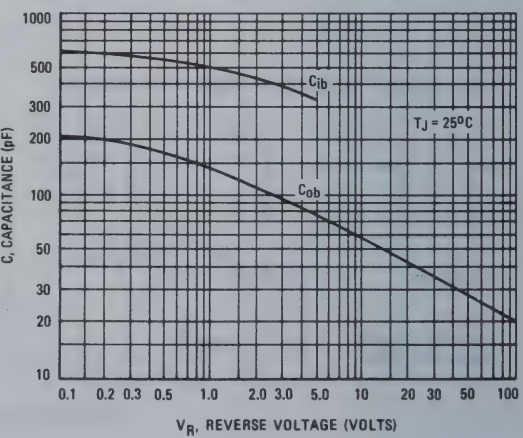


FIGURE 7 – CAPACITANCES



TYPICAL DC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

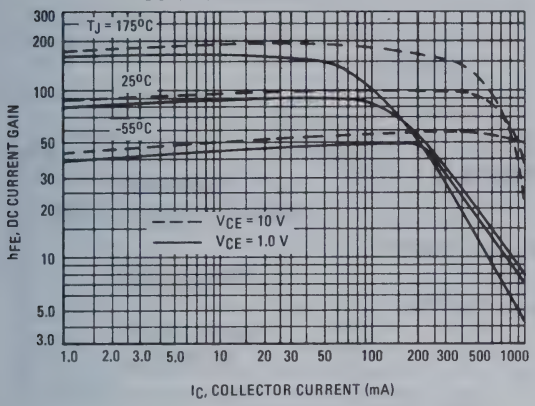


FIGURE 9 – COLLECTOR SATURATION REGION

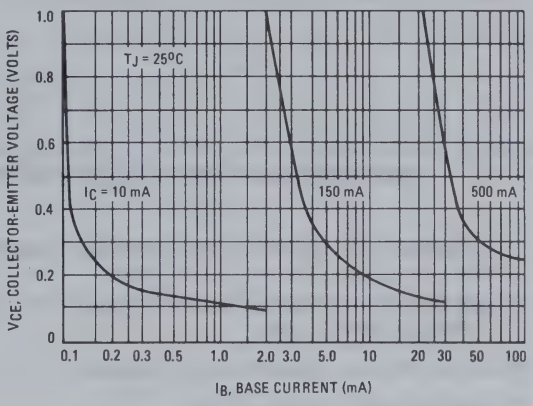


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

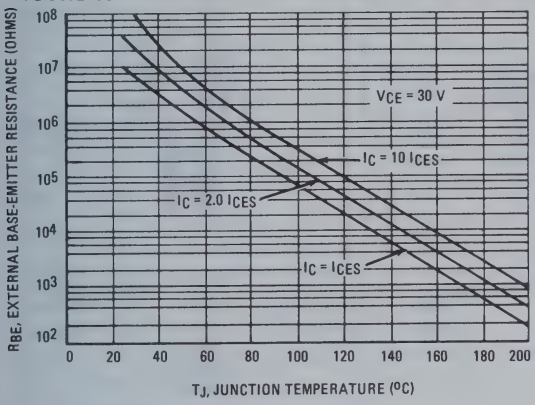


FIGURE 11 – "ON" VOLTAGES

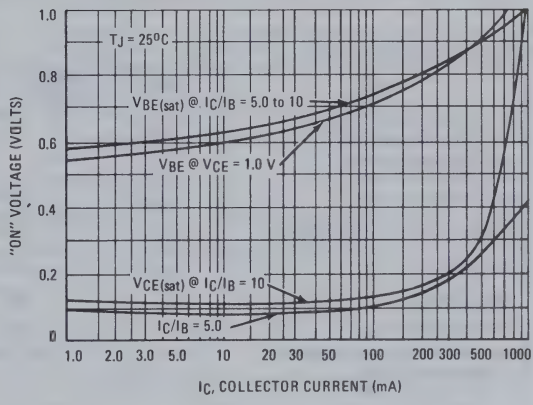


FIGURE 12 – COLLECTOR CUT-OFF REGION

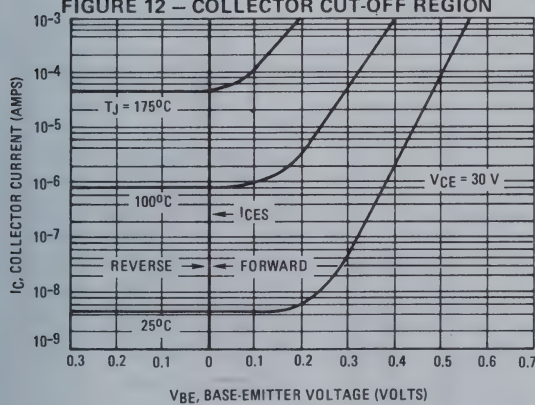
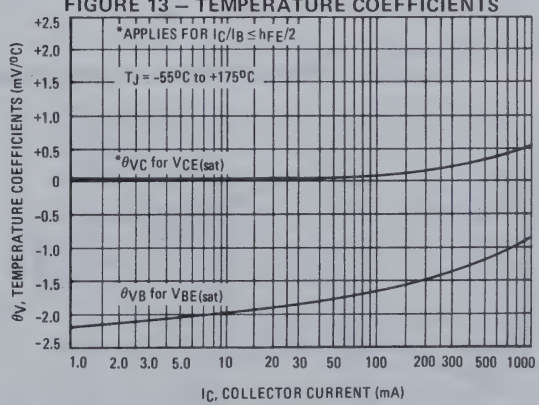


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5346 (SILICON) thru 2N5349

MEDIUM-POWER NPN SILICON TRANSISTORS

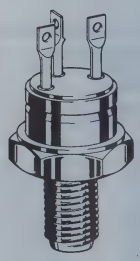
. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration

7 AMPERE POWER TRANSISTORS

NPN SILICON

80-100 VOLTS
60 WATTS



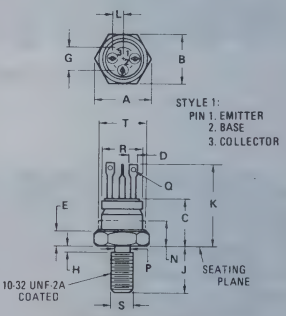
*MAXIMUM RATINGS

Rating	Symbol	2N5346 2N5347	2N5348 2N5349	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	60		Watts
Derate above 25°C		343		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

*Indicates JEDEC Registered Data

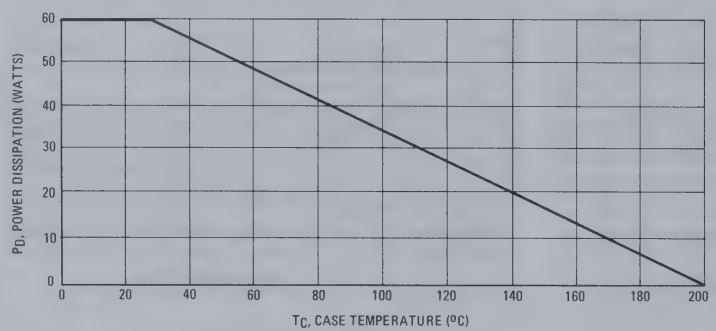


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	10.77	11.10	0.424	0.437
C	8.13	11.89	0.320	0.468
E	2.29	3.81	0.090	0.150
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	10.16	11.56	0.400	0.455
K	14.48	19.38	0.570	0.763
L	2.29	2.79	0.090	0.110
N	–	6.35	–	0.250
P	4.14	4.80	0.163	0.189
Q	1.02	1.65	0.040	0.065
R	8.08	9.65	0.318	0.380
S	4.212	4.310	0.1658	0.1697
T	9.65	11.10	0.380	0.437

All JEDEC dimensions and notes apply
Collector isolated from case.

TO-59
CASE 160-03
ISOLATED COLLECTOR

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	2N5346, 2N5347 2N5348, 2N5349	-	$V_{CEO(sus)}$	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5346, 2N5347	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5348, 2N5349			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5346, 2N5347	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5348, 2N5349			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5346, 2N5347			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5348, 2N5349			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348 2N5347, 2N5349	8	h_{FE}	30 60	- -	-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348 2N5347, 2N5349			30 60	120 240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348 2N5347, 2N5349			20 40	- -	
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		9,11,13	$V_{CE(sat)}$	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)		t_f	-	200	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

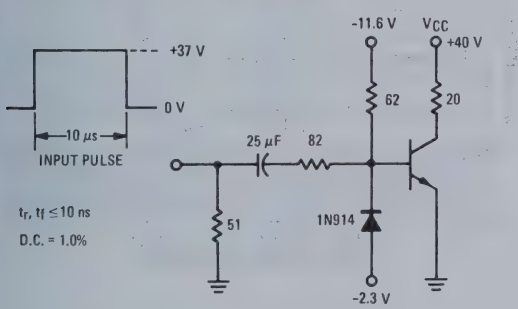


FIGURE 3 – TURN-ON TIME

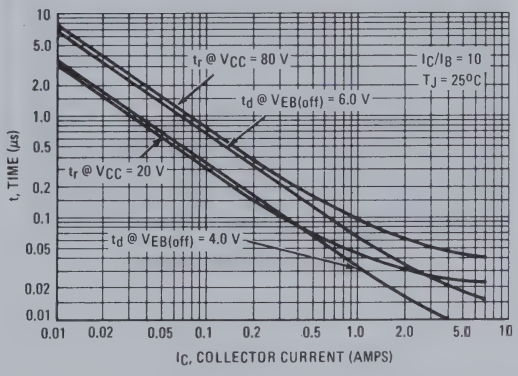


FIGURE 4 – THERMAL RESPONSE

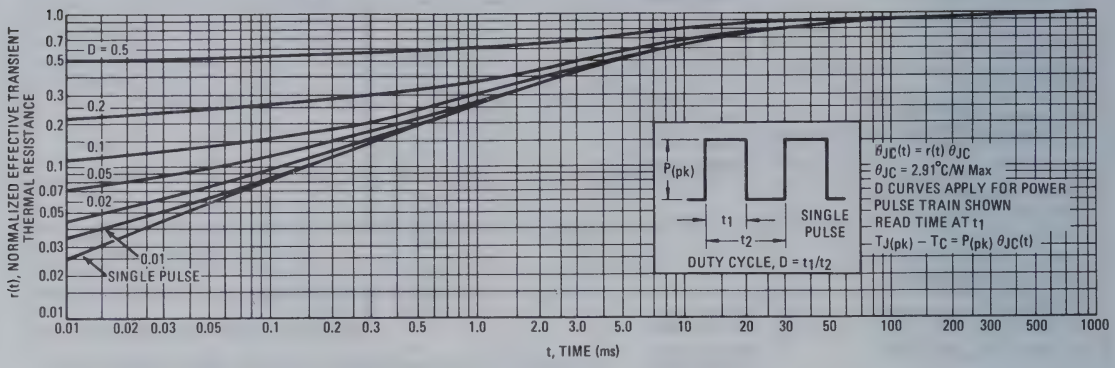
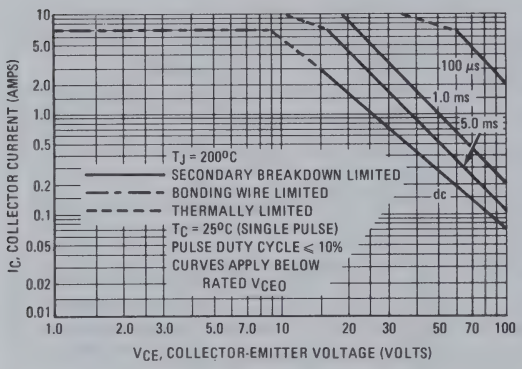


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

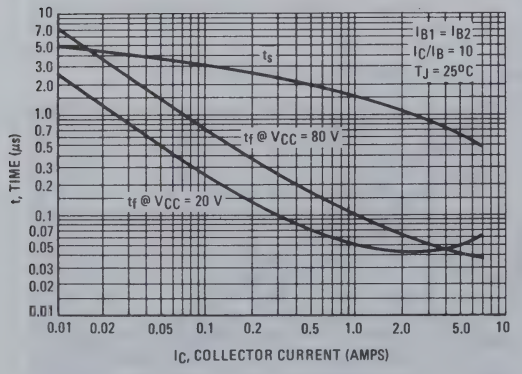


FIGURE 7 – CAPACITANCE versus VOLTAGE

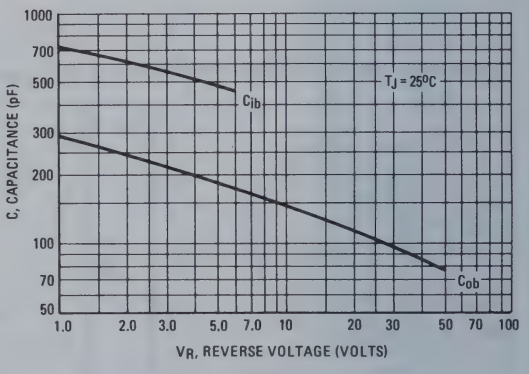


FIGURE 8 – DC CURRENT GAIN

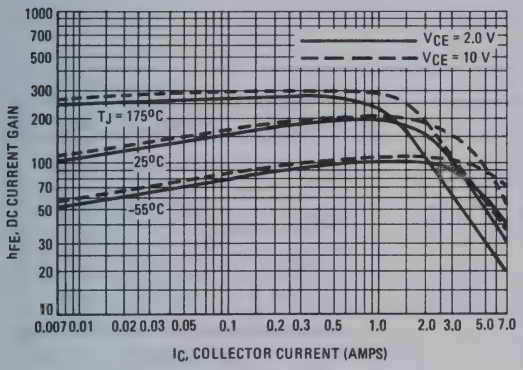


FIGURE 9 – COLLECTOR SATURATION REGION

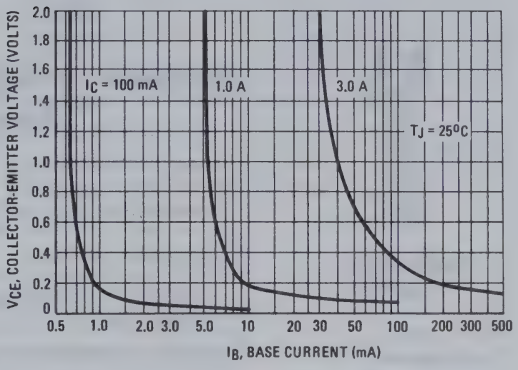


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

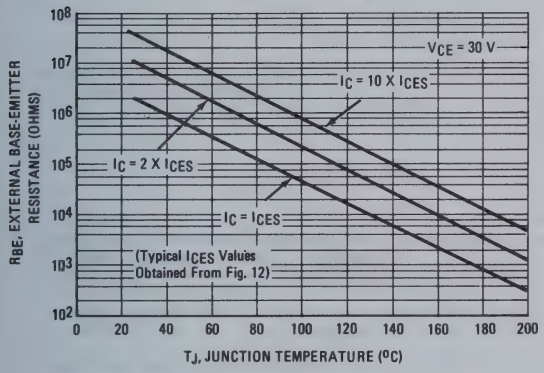


FIGURE 11 – "ON" VOLTAGES

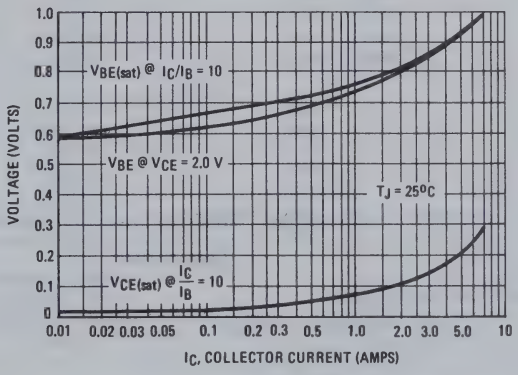


FIGURE 12 – COLLECTOR CUT-OFF REGION

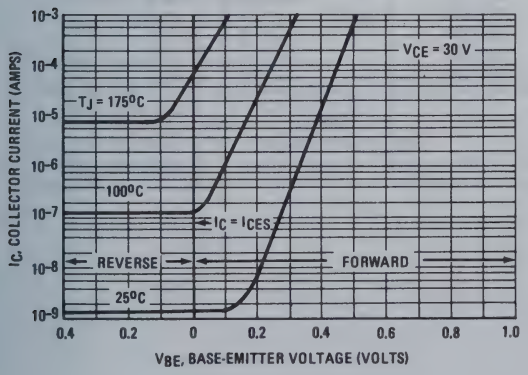
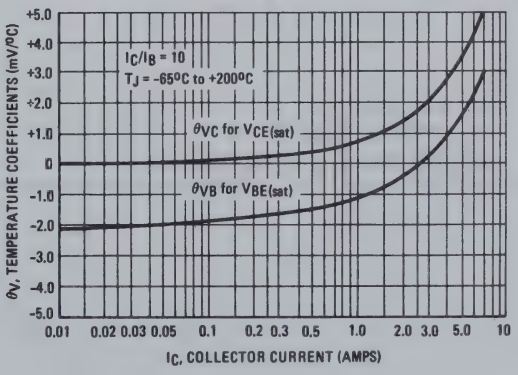


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5358 (SILICON) thru 2N5364

Silicon N-channel junction field-effect transistors depletion mode (Type A) devices designed primarily for general-purpose amplifier applications.



CASE 20(3)
(TO-72)

Pin 1. Drain
2. Source
3. Gate
4. Case Lead

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Forward Gate Current	$I_{G(f)}$	10	mAdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

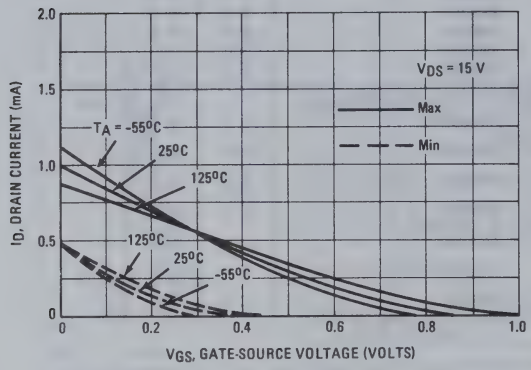
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 100 nAdc)	2N5358	$V_{GS(off)}$	0.5	3.0	Vdc
	2N5359		0.8	4.0	
	2N5360		0.8	4.0	
	2N5361		1.0	6.0	
	2N5362		2.0	7.0	
	2N5363		2.5	8.0	
	2N5364		2.5	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	0.1	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	0.1	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5358	I_{DSS}	0.5	1.0	mAdc
	2N5359		0.8	1.6	
	2N5360		1.5	3.0	
	2N5361		2.5	5.0	
	2N5362		4.0	8.0	
	2N5363		7.0	14	
	2N5364		9.0	18	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 15 Vdc, I_D = 50 μAdc)	2N5358		0.3	1.5	
(V_{DS} = 15 Vdc, I_D = 80 μAdc)	2N5359		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 150 μAdc)	2N5360		0.5	2.5	
(V_{DS} = 15 Vdc, I_D = 250 μAdc)	2N5361		1.0	5.0	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	2N5362		1.3	5.0	
(V_{DS} = 15 Vdc, I_D = 700 μAdc)	2N5363		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 900 μAdc)	2N5364		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5358	$\|y_{fs}\|$	1000	3000	μmhos
	2N5359		1200	3600	
	2N5360		1400	4200	
	2N5361		1500	4500	
	2N5362		2000	5500	
	2N5363		2500	6000	
	2N5364		2700	6500	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 100 MHz)	2N5358	$Re(y_{fs})$	800	-	μmhos
	2N5359		900	-	
	2N5360		1400	-	
	2N5361		1700	-	
	2N5362		1900	-	
	2N5363		2100	-	
	2N5364		2200	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5358, 2N5359	$\|y_{os}\|$	-	10	μmhos
	2N5360, 2N5361			20	
	2N5362, 2N5363			40	
	2N5364			60	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 – 2N5358



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 2 – 2N5358

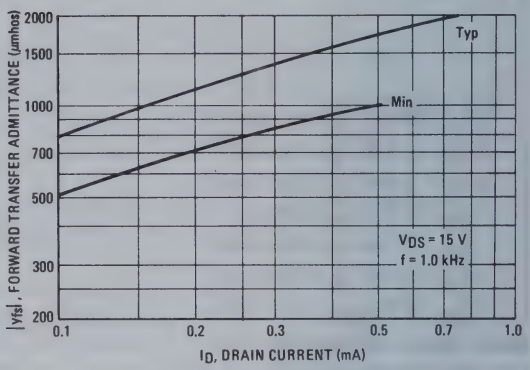


FIGURE 3 – 2N5359

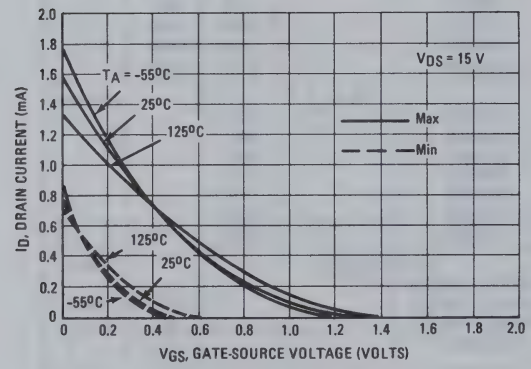


FIGURE 4 – 2N5359

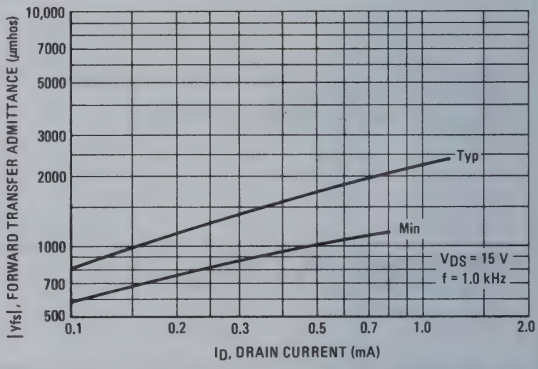


FIGURE 5 – 2N5360

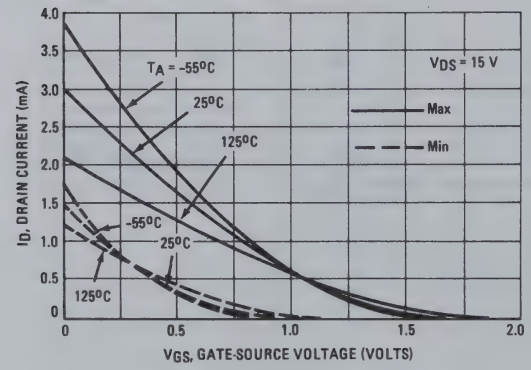
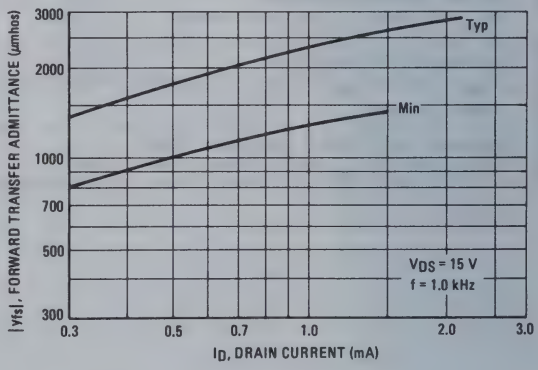
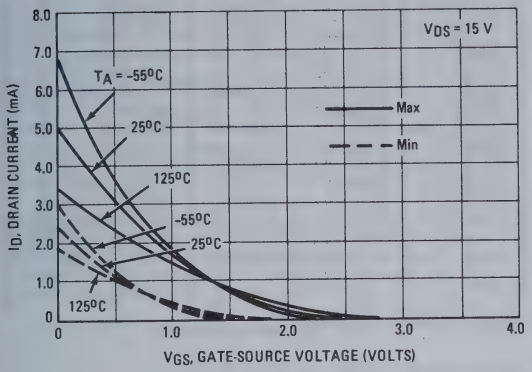


FIGURE 6 – 2N5360



DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 7 – 2N5361



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 8 – 2N5361

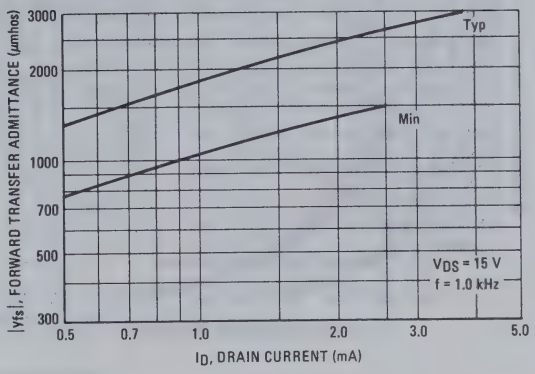


FIGURE 9 – 2N5362

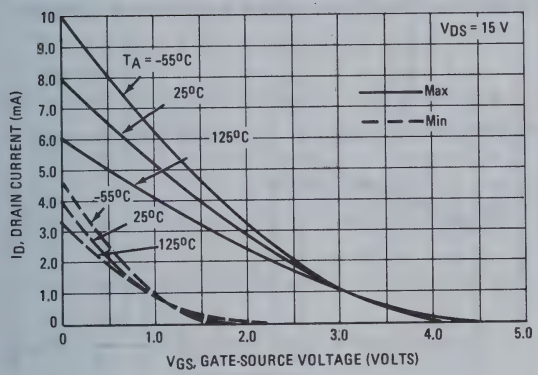


FIGURE 10 – 2N5362

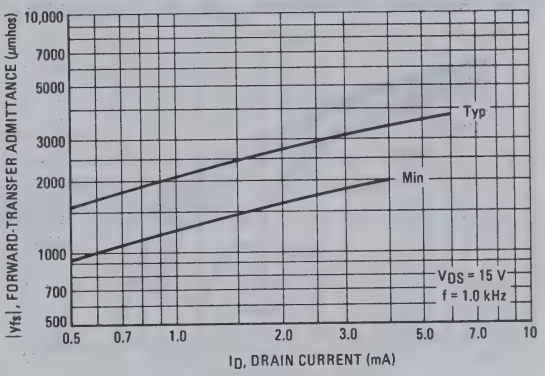


FIGURE 11 – 2N5363

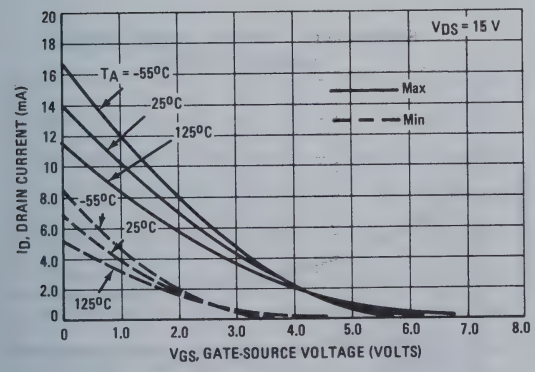
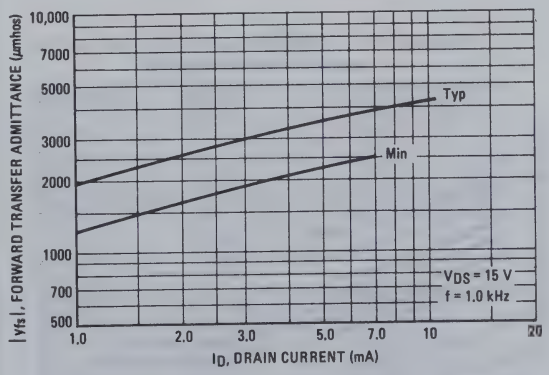
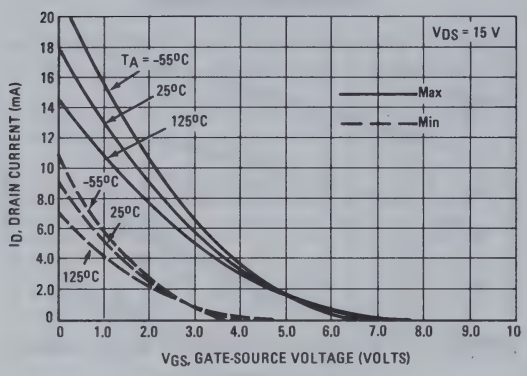


FIGURE 12 – 2N5363



DRAIN CURRENT versus
GATE-SOURCE VOLTAGE
FIGURE 13 – 2N5364



FORWARD TRANSFER ADMITTANCE
versus DRAIN CURRENT
FIGURE 14 – 2N5364

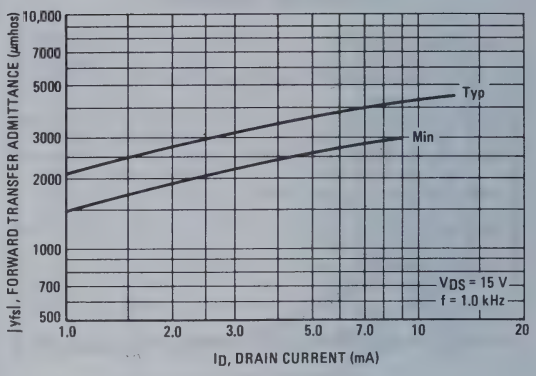


FIGURE 15 – TYPICAL DRAIN CURRENT
TEMPERATURE COEFFICIENT versus DRAIN CURRENT

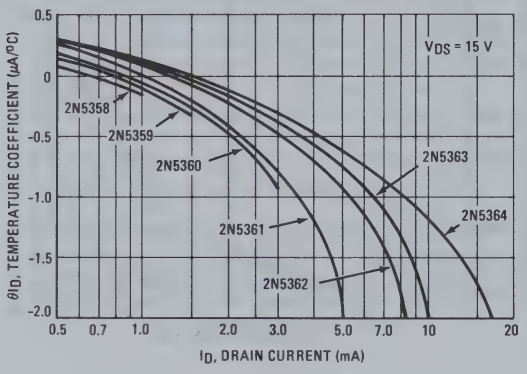


FIGURE 16 – TYPICAL FORWARD TRANSADMITTANCE
TEMPERATURE COEFFICIENT versus DRAIN CURRENT

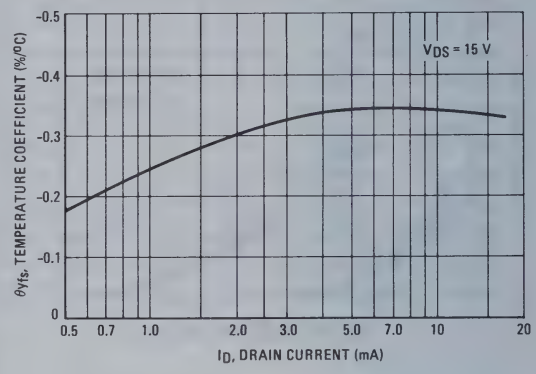


FIGURE 17 – TYPICAL OUTPUT RESISTANCE
versus DRAIN CURRENT

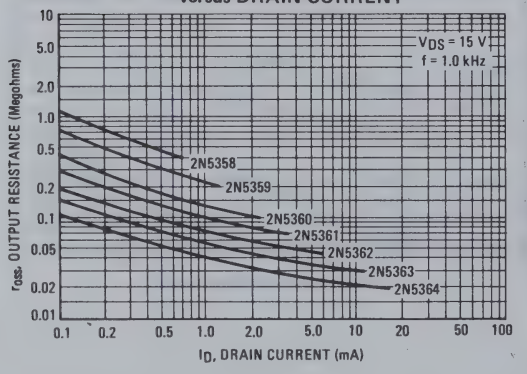


FIGURE 18 – TYPICAL CAPACITANCE
versus VOLTAGE

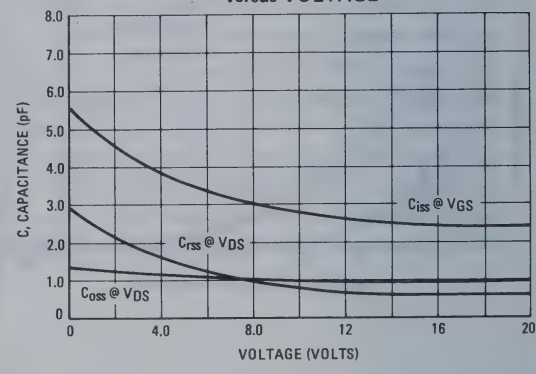


FIGURE 19 – TYPICAL NOISE FIGURE versus FREQUENCY

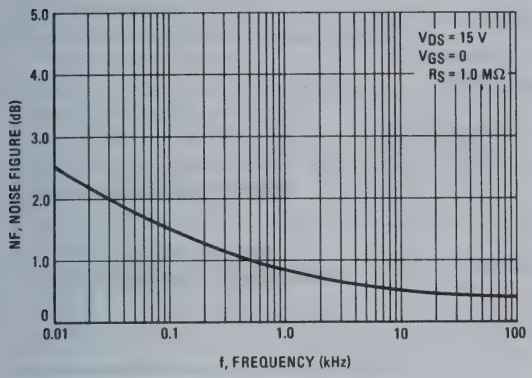


FIGURE 20 – TYPICAL NOISE FIGURE versus SOURCE RESISTANCE

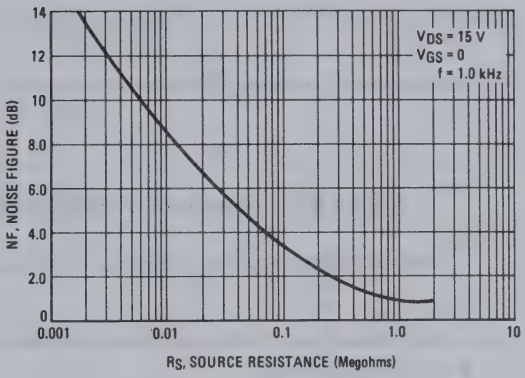
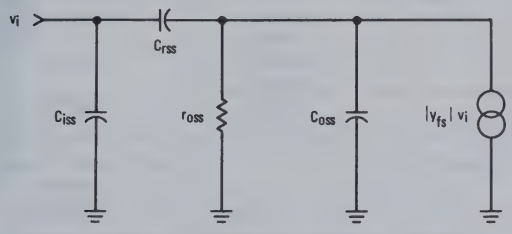


FIGURE 21 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$
$y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5400 (SILICON)
2N5401

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier applications.

- High Voltage Ratings — BV_{CEO} = 120 and 150 Vdc (Min)
- Low Saturation Voltage
  ($V_{CE(sat)}$ = 0.25 V (max) @ I_C = 50 mA
- Current Gain Specified from 1.0 mAdc to 50 mAdc

HIGH VOLTAGE

PNP SILICON AMPLIFIER TRANSISTORS



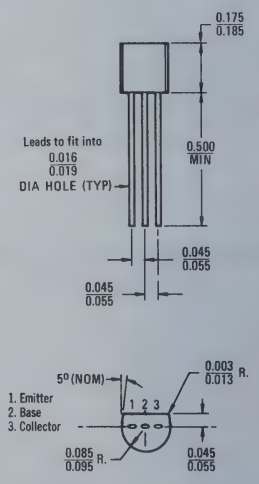
*MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	120	150	Vdc
Collector-Base Voltage	V_{CB}	130	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C	P_D (1)	310		mW
Derate above 25°C		2.81		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	−55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29-02
TO-92

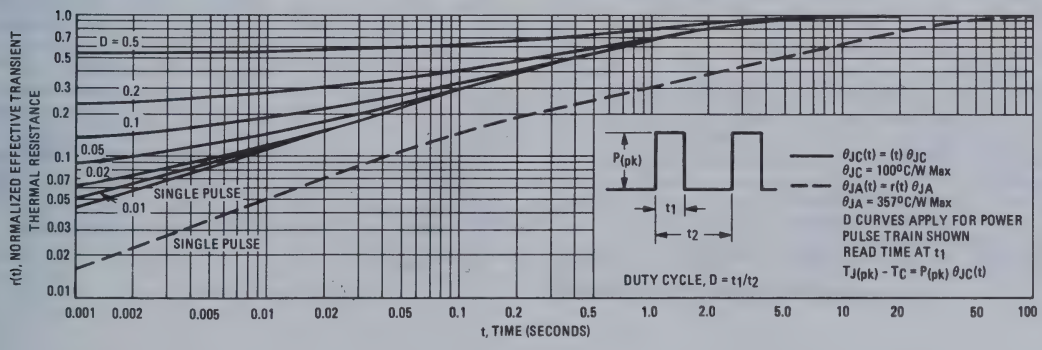
*Indicates JEDEC Registered Data

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CEO}			Vdc
(I_C = 1.0 mAdc, I_B = 0)	2N5400		120	–	
	2N5401		150	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N5400		130	–	
	2N5401		160	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5.0	–	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5400		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	2N5401		–	50	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	2N5400		–	100	μAdc
(V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	2N5401		–	50	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 3.0 Vdc, I_C = 0)			–	50	
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5400		30	–	
	2N5401		50	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	180	
	2N5401		60	240	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	–	
	2N5401		50	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.20	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.25	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N5400		100	400	
	2N5401		100	300	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)			–	6.0	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400		30	200	
	2N5401		40	200	
Noise Figure		NF			dB
(I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)			–	8.0	

*Indicates JEDEC Registered Data
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

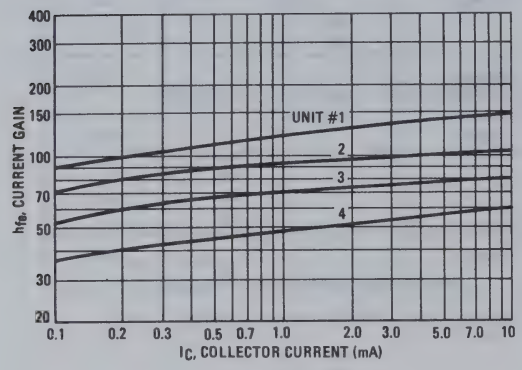


FIGURE 3 – OUTPUT ADMITTANCE

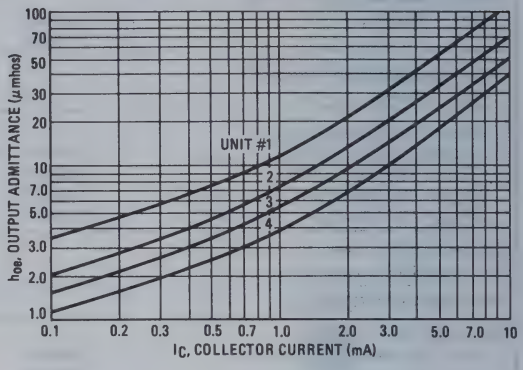


FIGURE 4 – INPUT IMPEDANCE

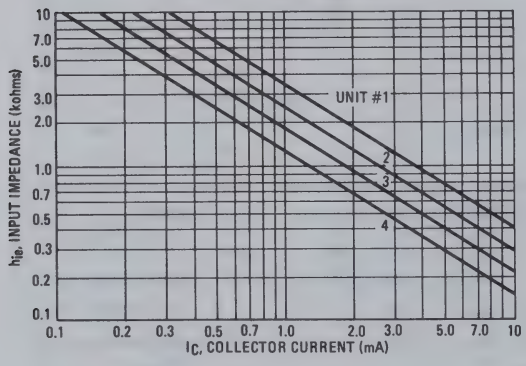


FIGURE 5 – VOLTAGE FEEDBACK RATIO

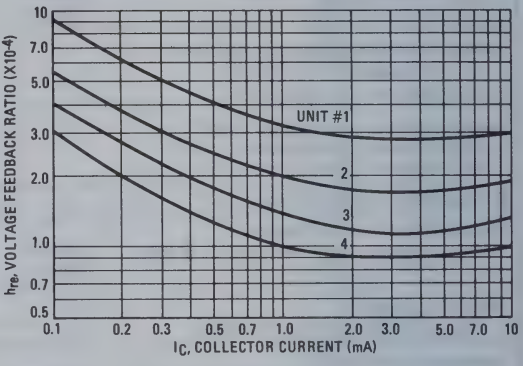
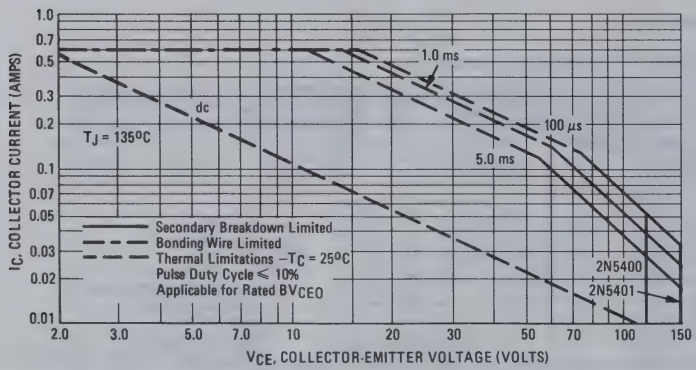


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 135°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

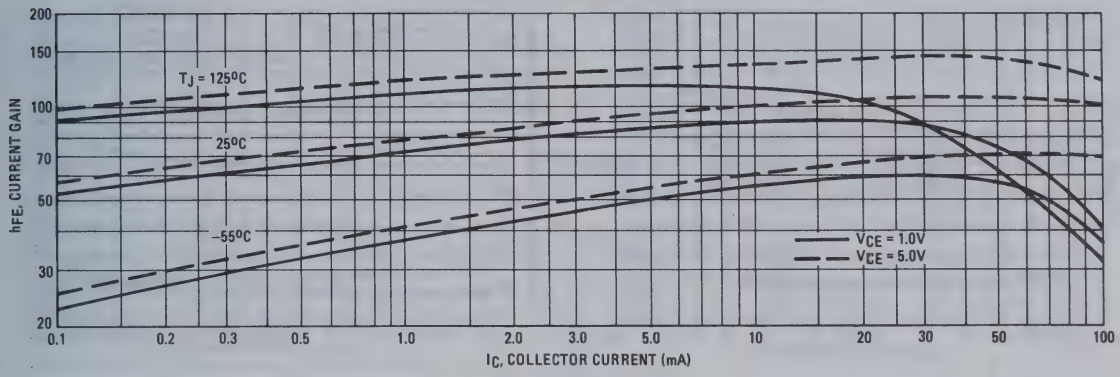


FIGURE 8 – COLLECTOR SATURATION REGION

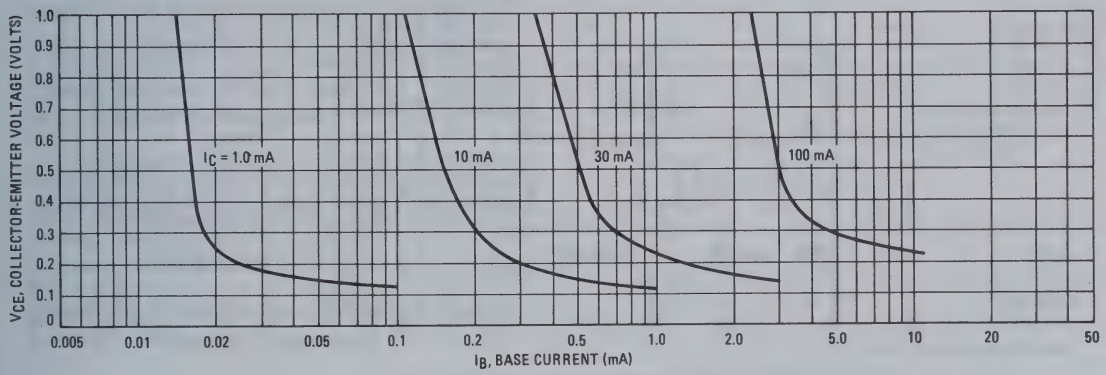


FIGURE 9 – COLLECTOR CUT-OFF REGION

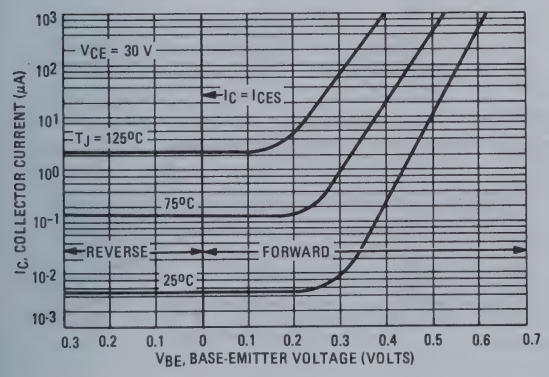


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

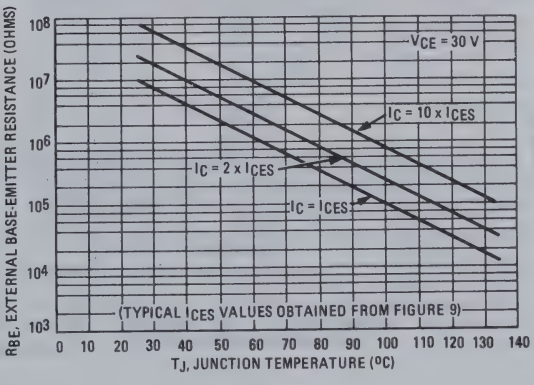


FIGURE 11 – "ON" VOLTAGES

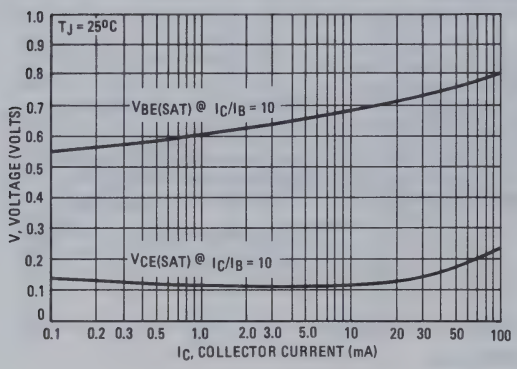


FIGURE 12 – TEMPERATURE COEFFICIENTS

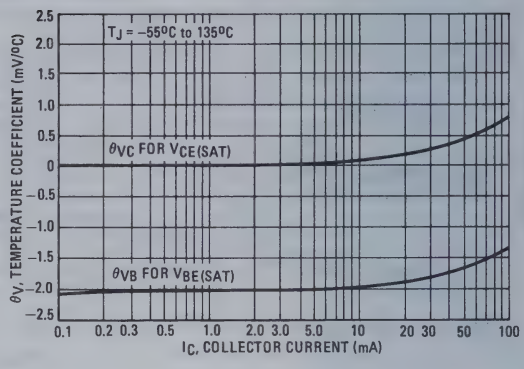


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

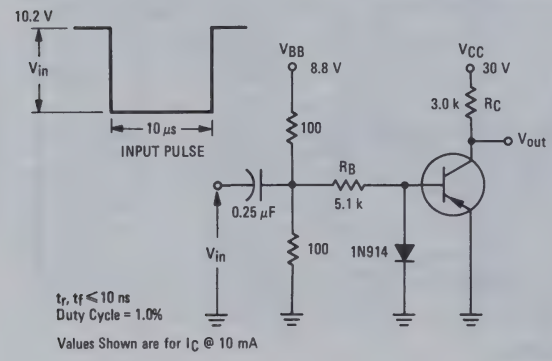


FIGURE 14 – CAPACITANCES

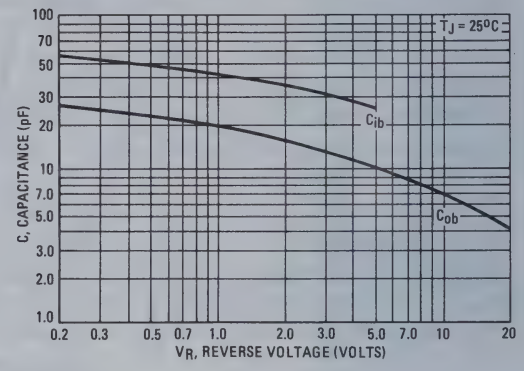


FIGURE 15 – TURN-ON TIME

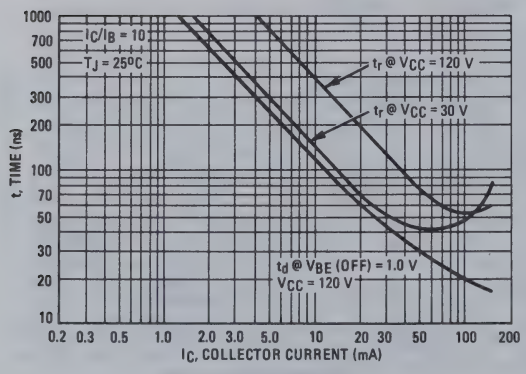
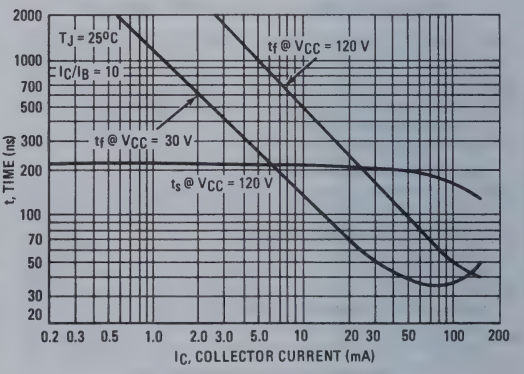


FIGURE 16 – TURN-OFF TIME



2N5427 (SILICON)
thru
2N5430



CASE 80
(TO-66)
Collector connected to case

Medium-power NPN silicon transistors designed for switching and wide-band amplifier applications.

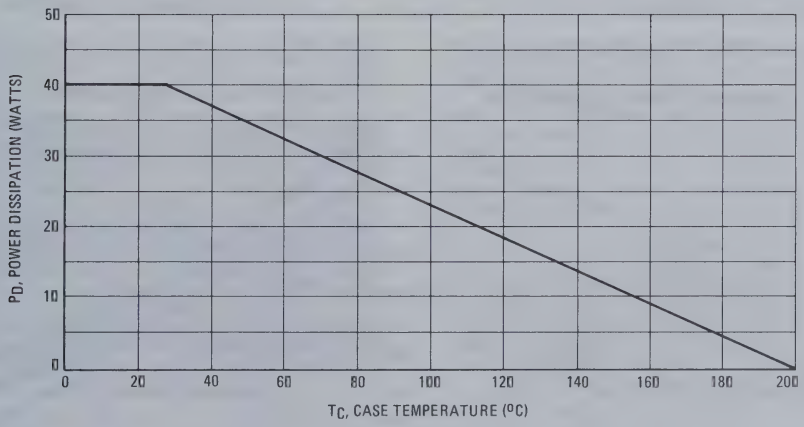
MAXIMUM RATINGS

Rating	Symbol	2N5427 2N5428	2N5429 2N5430	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	40		Watts
Derate above 25°C		228		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.37	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	2N5427, 2N5428 2N5429, 2N5430	-	$BV_{CEO(sus)}$	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5427, 2N5428		I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5429, 2N5430			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5427, 2N5428	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5429, 2N5430			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5427, 2N5428			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5429, 2N5430			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430	8	h_{FE}	30 60	- -	-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430			30 60	120 240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430			20 40	- -	
Collector-Emitter Saturation Voltage (1) (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage (1) (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	2,3	t_d	-	100	ns
Rise Time			t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc, I_{B1} = I_{B2} = 200 mAdc)	2,6	t_s	-	2.0	μs
Fall Time			t_f	-	200	ns

(1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

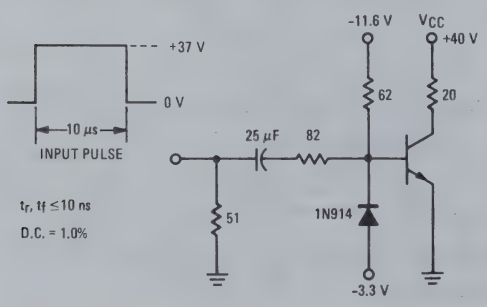


FIGURE 3 — TURN-ON TIME

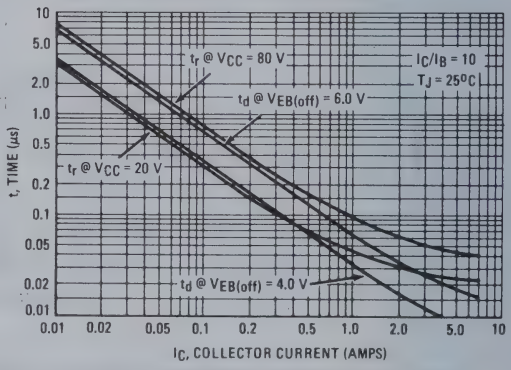


FIGURE 4 – THERMAL RESPONSE

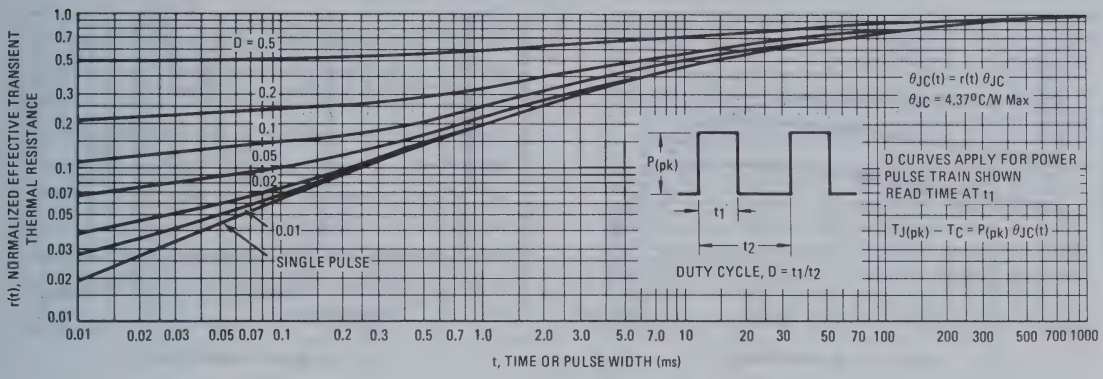
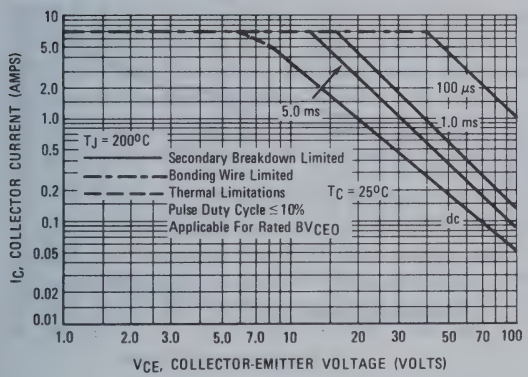


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

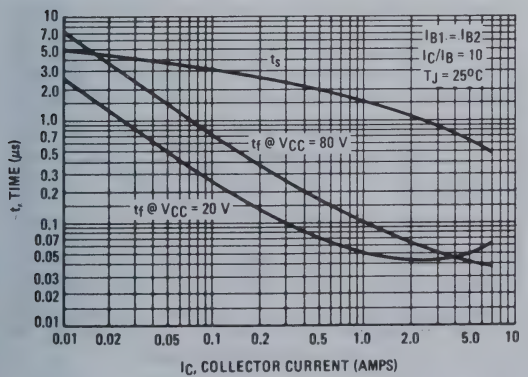


FIGURE 7 – CAPACITANCE versus VOLTAGE

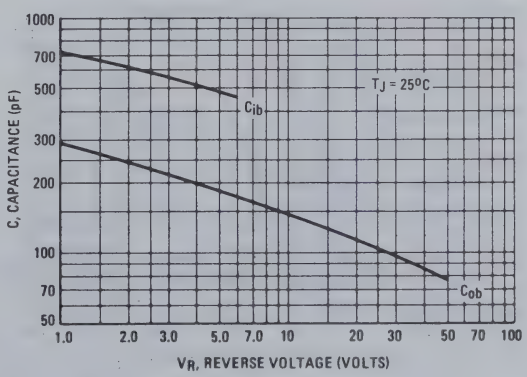


FIGURE 8 – DC CURRENT GAIN

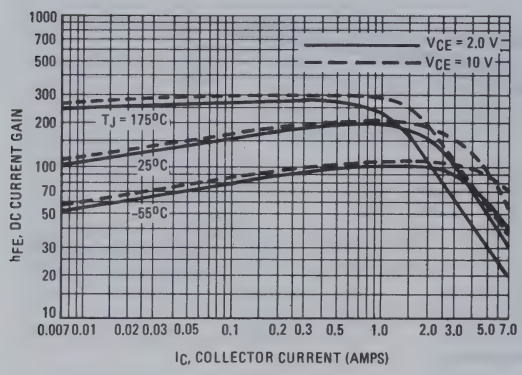


FIGURE 9 – COLLECTOR SATURATION REGION

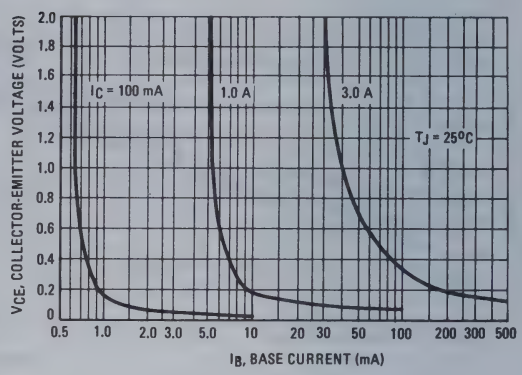


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

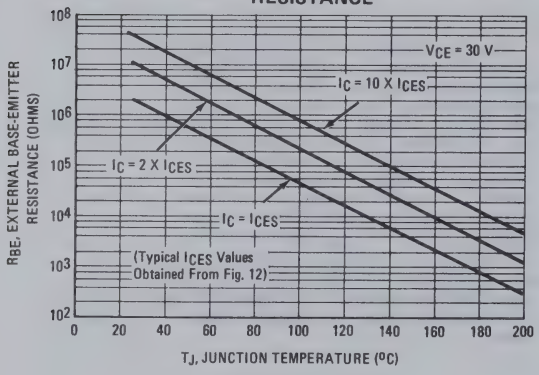


FIGURE 11 – "ON" VOLTAGES

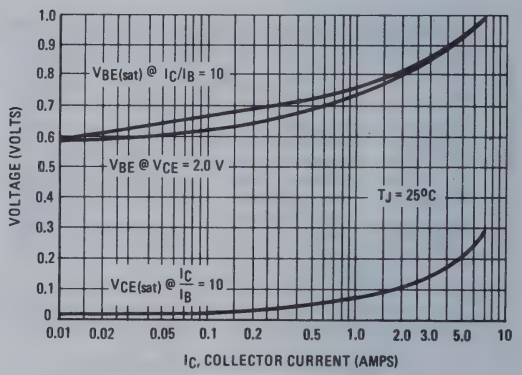


FIGURE 12 – COLLECTOR CUT-OFF REGION

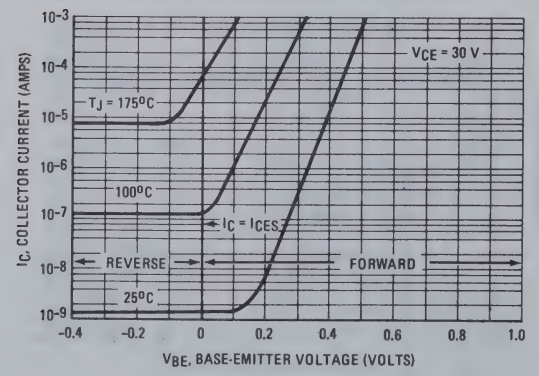
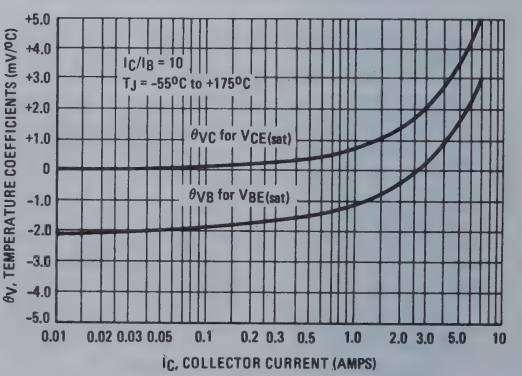


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5431 (SILICON)



CASE 22A
(TO-18 Modified)
Lead 3 connected to case

Silicon annular unijunction transistors characterized primarily for low interbase-voltage operation in sensing, pulse triggering, and timing circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current **	i_e**	1.5	A
Emitter Reverse Voltage	V_{B2E}	30	V
Interbase Voltage ‡	V_{B2B1}‡	35	V
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Derate 3.0 mW/°C increase in ambient temperature.
**Duty Cycle ≤ 1.0%, PRR = 10 PPS (see figure 5).
‡Based upon power dissipation at T_A = 25°C.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

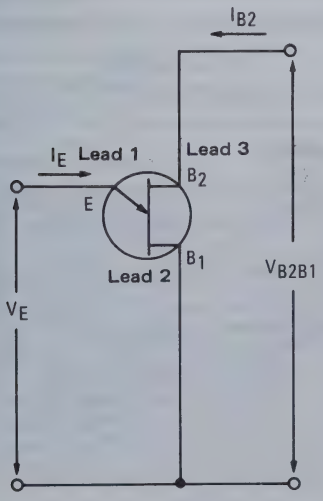
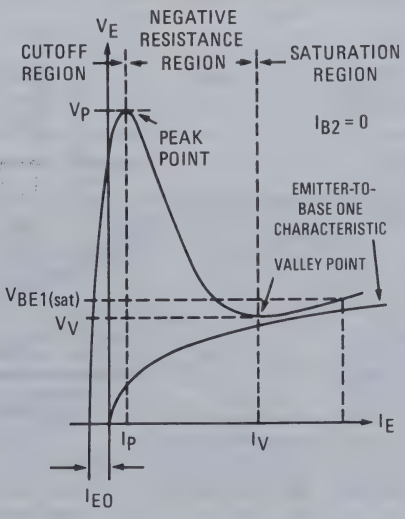


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Intrinsic Standoff Ratio ① (V_{B2B1} = 10 V)	4	η ①	0.72	0.80	-
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		R_{BB}	6.0	8.5	kΩ
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = 0 to 100°C)		αR_{BB}	0.4	0.8	%/°C
Emitter Saturation Voltage ② (V_{B2B1} = 10 V, I_E = 50 mA)		$V_{EB1(sat)}$ ②	-	3.0	V
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	5.0	30	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}	-	10	nA
Peak-Point Emitter Current (V_{B2B1} = 25 V) (V_{B2B1} = 4.0 V)		I_P	- -	0.4 4.0	μA
Valley-Point Current ② (V_{B2B1} = 20 V, R_{B2} = 100 ohms)		I_V ②	2.0	-	mA
Base-One Peak Pulse Voltage (V_{BB} = 4.0 volts)	3	V_{OB1}	1.0	-	V

①η, Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

② Use pulse techniques: PW ≈ 300 μs, Duty Cycle ≤ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

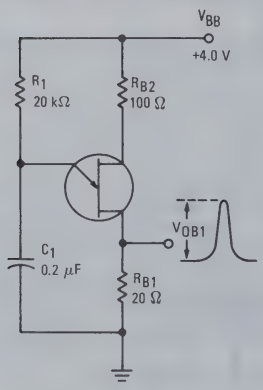
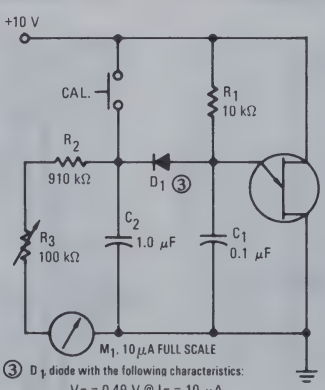


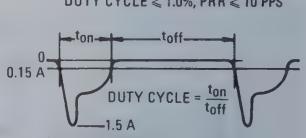
FIGURE 4 — η TEST CIRCUIT



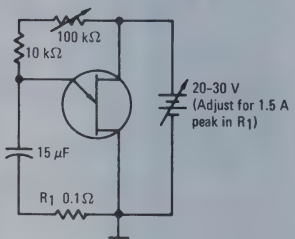
③ D_1 diode with the following characteristics:
V_F = 0.49 V @ I_F = 10 μA
$I_R \leq$ 2.0 μA @ V_R = 20 V

FIGURE 5 — PRR TEST CIRCUIT AND WAVEFORM

DUTY CYCLE ≤ 1.0%, PRR ≤ 10 PPS

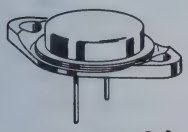


CURRENT WAVEFORM THRU R_1

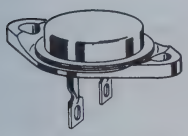


2N5435 (GERMANIUM) thru 2N5440

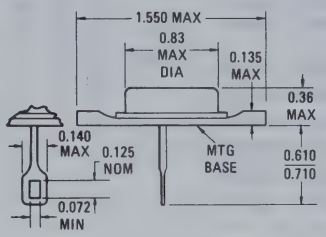
PNP germanium power switching transistors designed for high-current, fast-switching applications requiring low saturation voltage and excellent safe operating area.

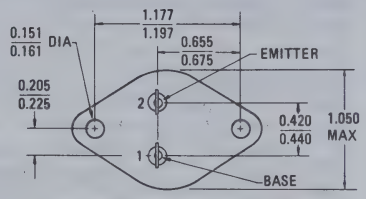


CASE 3-04
TO-3 Package
2N5435/5440



CASE 161
TO-41 Package
MP5435/5440





Collector Connected to Case
CASE 161 (TO-41)
CASE 3A (TO-3) ALL DIMENSIONS IDENTICAL
EXCEPT PINS – 0.060/0.065 DIA X 0.061/0.071 LONG

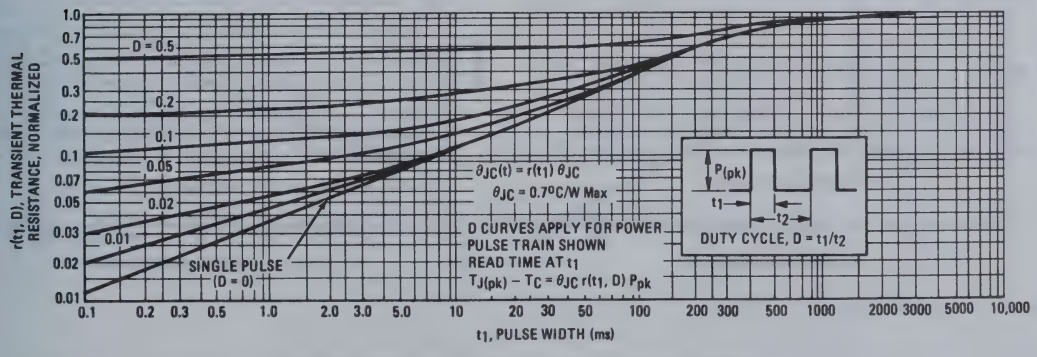
MAXIMUM RATINGS **

Rating	Symbol	2N5435 2N5438	2N5436 2N5439	2N5437 2N5440	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	120	Vdc
Collector-Base Voltage	V_{CB}	80	110	140	Vdc
Emitter-Base Voltage	V_{EB}	2.5			Vdc
Collector Current — Continuous	I_C	60			Adc
Base Current — Continuous	I_B	12			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	120 1.43			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	°C/W

FIGURE 1 – THERMAL RESPONSE



**Maximum Ratings for MP5435 Series are the Same as the 2N5435 Series.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)**

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5435, 2N5438	BV_{CEO}	60	-	Vdc
	2N5436, 2N5439		90	-	
	2N5437, 2N5440		120	-	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5435, 2N5438		-	10	
(V_{CE} = 110 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5436, 2N5439		-	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5437, 2N5440		-	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5435, 2N5438		-	30	
(V_{CE} = 110 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5436, 2N5439		-	30	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5437, 2N5440		-	30	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	200	μAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	-	500	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 25 Adc, V_{CE} = 2.0 Vdc)	2N5435, 2N5436, 2N5437	h_{FE}*	20	60	-
	2N5438, 2N5439, 2N5440		40	120	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)	2N5435, 2N5436, 2N5437		10	-	
	2N5438, 2N5439, 2N5440		15	-	
Collector-Emitter Saturation Voltage* (I_C = 60 Adc, I_B = 6.0 Adc)	2N5435, 2N5436, 2N5437	$V_{CE(sat)}$*	-	0.75	Vdc
	2N5438, 2N5439, 2N5440		-	0.50	
Base-Emitter Saturation Voltage* (I_C = 60 Adc, I_B = 6.0 Adc)	2N5435, 2N5436, 2N5437	$V_{BE(sat)}$*	-	1.2	Vdc
	2N5438, 2N5439, 2N5440		-	0.9	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	350	-	kHz
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 25 Adc, I_{B1} = 2.5 Adc, I_{B2} = 2.5 Adc) (See Figure 4)	t_r	-	12	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

**Electrical Characteristics for MP5435 series are the same as the 2N5435 series.
* To avoid excessive heating of the collector junction, perform test with pulse method.

FIGURE 2 – POWER-TEMPERATURE DERATING CURVE

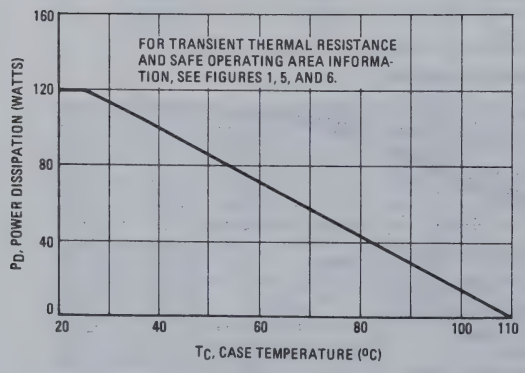


FIGURE 3 – SWITCHING TIMES

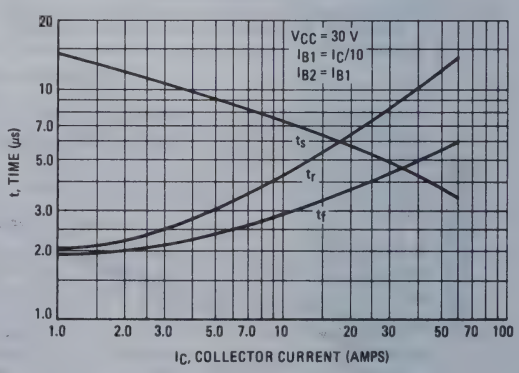


FIGURE 4 – SWITCHING TIME TEST CIRCUIT

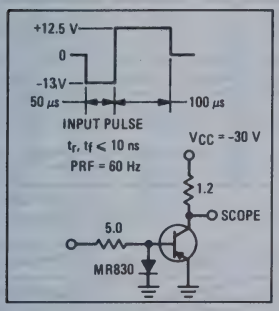
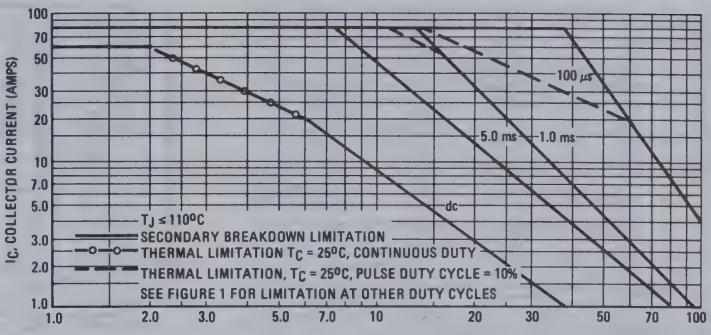


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 110°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – CLAMPED INDUCTIVE SAFE OPERATING AREA

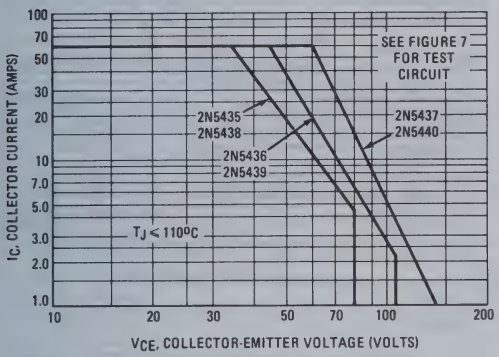


FIGURE 7 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT

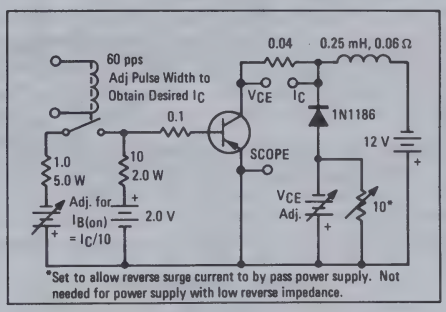


FIGURE 8 – DC CURRENT GAIN

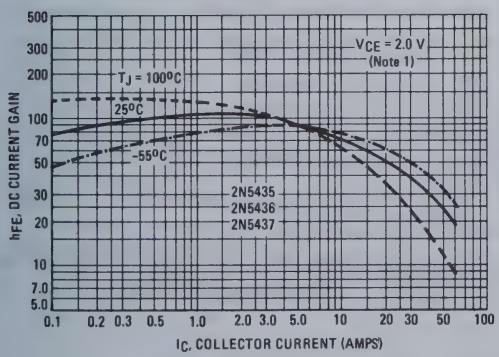
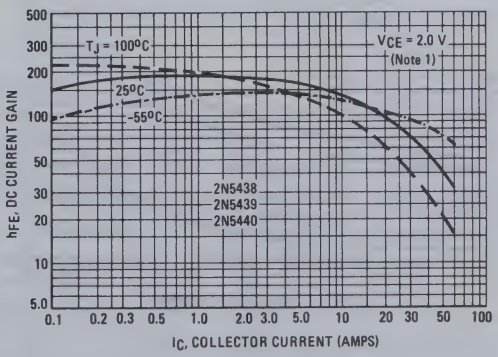


FIGURE 9 – DC CURRENT GAIN



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

FIGURE 10 – COLLECTOR SATURATION REGION

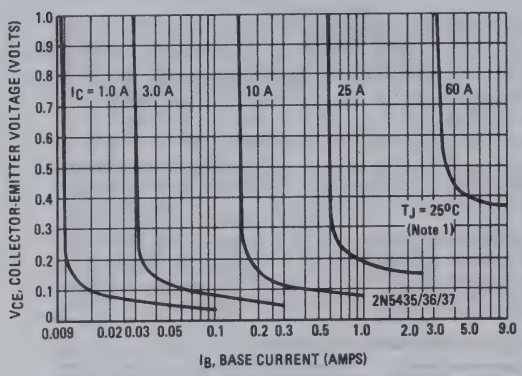


FIGURE 11 – COLLECTOR SATURATION REGION

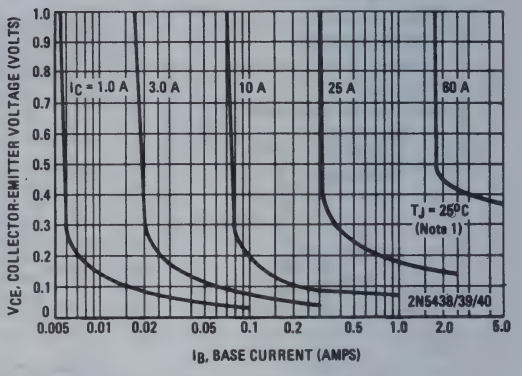


FIGURE 12 – EFFECTS OF BASE-EMITTER RESISTANCE

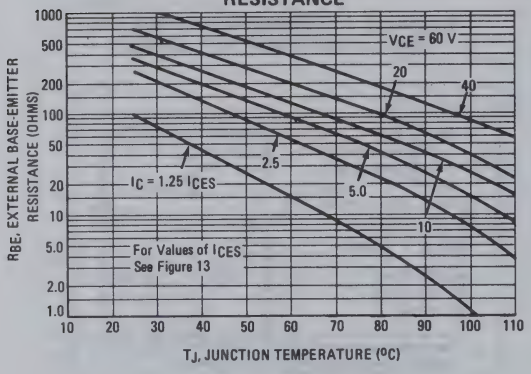


FIGURE 13 – COLLECTOR CUTOFF REGION

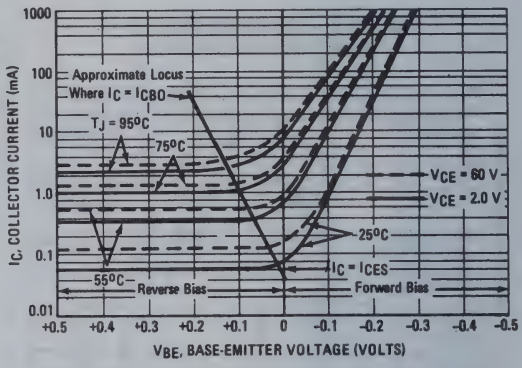


FIGURE 14 – "ON" VOLTAGES

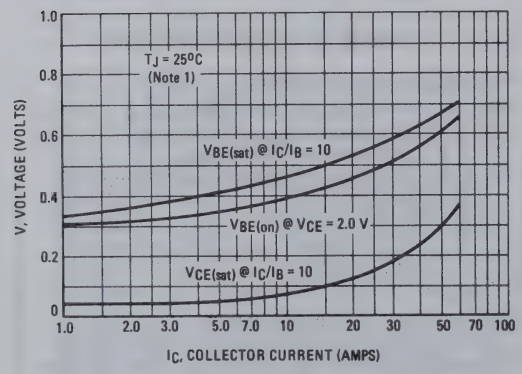
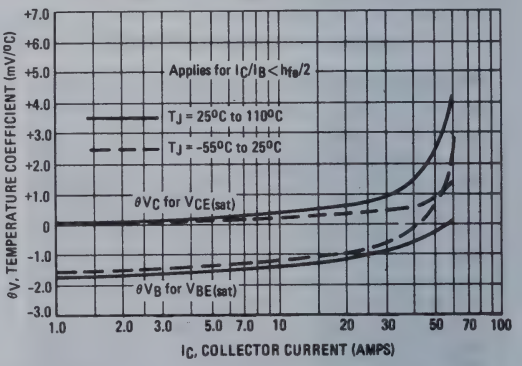


FIGURE 15 – TEMPERATURE COEFFICIENTS



2N5441 thru 2N5446 (SILICON)
MAC40688 thru MAC40690



SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

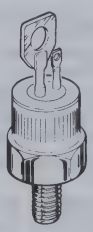
- Glass Passivated Junctions and Center Gate Fire
- Isolated Stud for Ease of Assembly
- Gate Triggering Guaranteed In All 4 Quadrants

TRIACS
(THYRISTORS)
40 AMPERES RMS



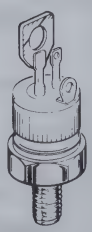
2N5441
2N5442
2N5443

CASE 237



2N5444
2N5445
2N5446

CASE 238



MAC40688
MAC40689
MAC40690

CASE 239

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage (1) (T_J = -65 to +110°C) 1/2 Sine Wave 50 to 60 Hz, Gate Open *Peak Principal Voltage	V_{DRM}		Volts
2N5441, 2N5444, MAC40688		200	
2N5442, 2N5445, MAC40689		400	
2N5443, 2N5446, MAC40690		600	
*Peak Gate Voltage	V_{GM}	30	Volts
*On-State Current RMS (T_C = -65 to +70°C)	$I_{T(RMS)}$	40	Amp
(T_C = +100°C)		20	
Full Sine Wave, 50 to 60 Hz			
*Peak Surge Current (One Full Cycle of surge current at 60 Hz, preceeded and followed by a 40 A RMS current, T_J = +110°C)	I_{TSM}	300	Amp
*Peak Gate Power (Pulse Width = 10 μs Max)	P_{GM}	40	Watts
*Average Gate Power	$P_{G(AV)}$	0.75	Watt
*Peak Gate Current (10 μs Max)	I_{GM}	4.0	Amp
*Operating Junction Temperature Range	T_J	-65 to +110	°C
*Storage Temperature Range	T_{stg}	-65 to +150	°C
*Stud Torque	—	30	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
2N5441, 2N5442, 2N5443		0.8	
2N5444, 2N5445, 2N5446		0.9	
MAC40688, MAC40689, MAC40690		1.0	

*Indicates JEDEC Registered Data for 2N5441 thru 2N5446.

(1) Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

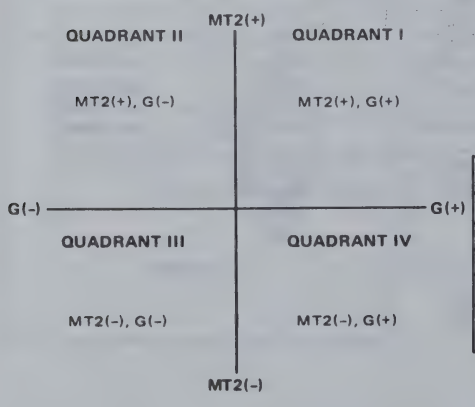
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	0.5	4.0	mA
*On-State Voltage (Either Direction) I_{TM} = 56 A Peak, Pulse Width ≤ 1.0 ms, Duty Cycle ≤ 2.0%	V_{TM}	–	1.65	1.85	Volts
Gate Trigger Current (1) Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms	I_{GT}				mA
MT2 (+), G(+)		–	15	70	
MT2 (+), G(–)		–	15	70	
MT2 (–), G(–)		–	15	70	
MT2 (–), G(+)		–	20	100	
*MT2 (+), G(+); MT2 (–), G (–) T_C = –65°C		–	–	125	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –65°C		–	–	240	
Gate Trigger Voltage Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms	V_{GT}				Volts
MT2 (+), G(+)		–	1.1	2.0	
MT2 (+), G(–)		–	1.1	2.0	
MT2 (–), G(–)		–	1.1	2.0	
MT2 (–), G(+)		–	1.3	2.5	
*All Quadrants, T_C = –65°C)		–	–	3.4	
*Main Terminal Voltage = Rated V_{DRM} = R_L = 10 k ohms, T_J = +110°C		0.2	–	–	
Holding Current Main Terminal Voltage = 12 Vdc, Gate Open Initiating Current = 150 mA	I_H				mA
MT2 (+)		–	10	70	
MT2 (–)		–	10	70	
*Either Direction, T_C = –65°C		–	–	100	
*Turn-On Time Main Terminal Voltage = Rated V_{DRM}, I_{TM} = 56 A, Gate Source Voltage = 12 V, R_S = 12 Ohms, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	t_{gt}	–	1.0	2.0	μs
*Critical Rate-of -Rise of Commutation Voltage Rated V_{DRM}, I_{TM} = 40 A, Commutating di/dt = 22 A/ms, gate energized	dv/dt				V/μs
T_C = 70°C 2N5441, 2N5442, 2N5443		5.0	30	–	
= 65°C 2N5444, 2N5445, 2N5446		5.0	30	–	
= 60°C MAC40688, MAC40689, MAC40690		5.0	30	–	
Rated V_{DRM}, Exponential Voltage Rise, Gate Open, T_C = 110°C					
2N5441, 2N5444, MAC40688		50			
2N5442, 2N5445, MAC40689		30			
2N5443, 2N5446, MAC40690		20			

*Indicates JEDEC Registered Data for 2N5441 thru 2N5446.

(1) All voltage polarity referenced to Main Terminal 1.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – POWER DISSIPATION versus ON-STATE CURRENT

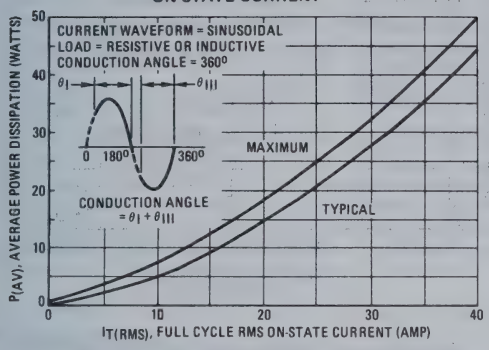


FIGURE 2 – CASE TEMPERATURE versus ON-STATE CURRENT

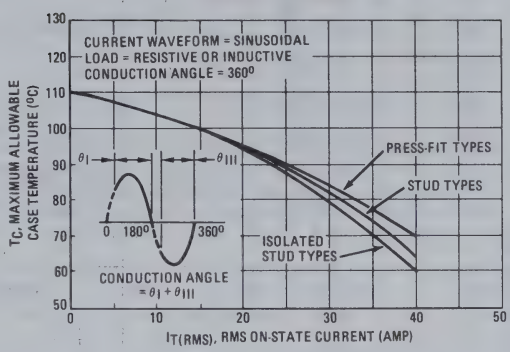


FIGURE 3 – TYPICAL GATE TRIGGER VOLTAGE

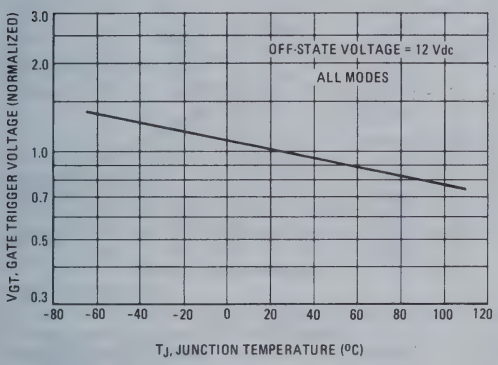


FIGURE 4 – TYPICAL GATE TRIGGER CURRENT

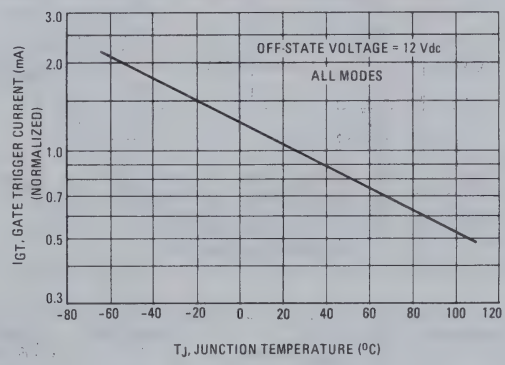


FIGURE 5 – TYPICAL THERMAL RESPONSE

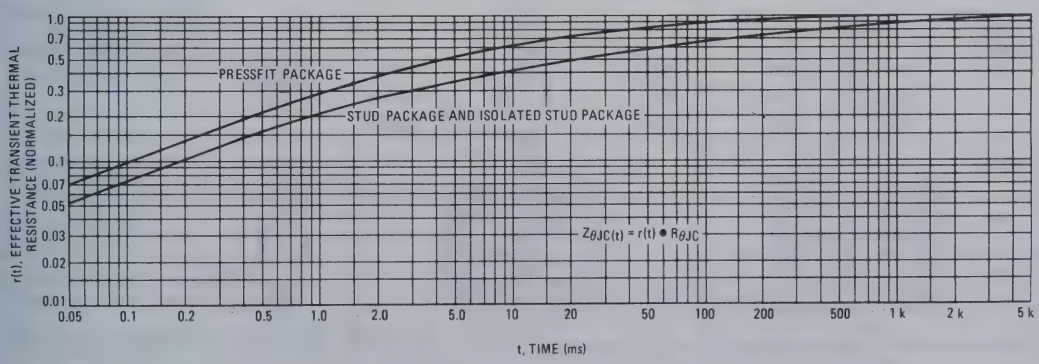


FIGURE 6 – MAXIMUM ON-STATE CHARACTERISTICS

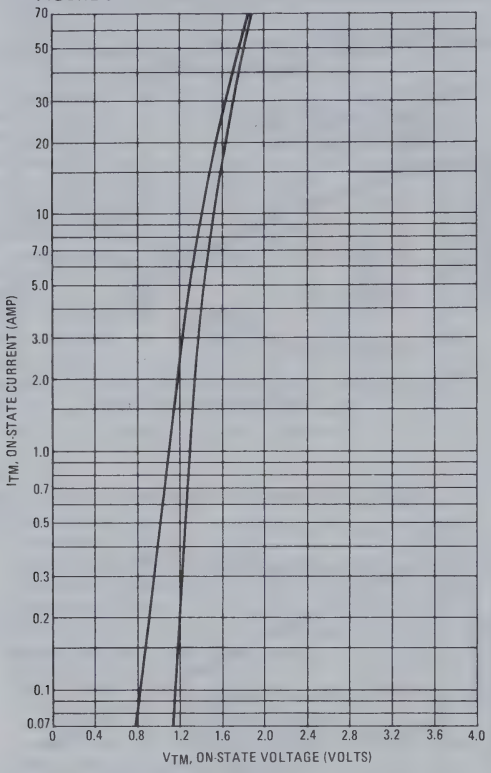


FIGURE 7 – TYPICAL HOLDING CURRENT

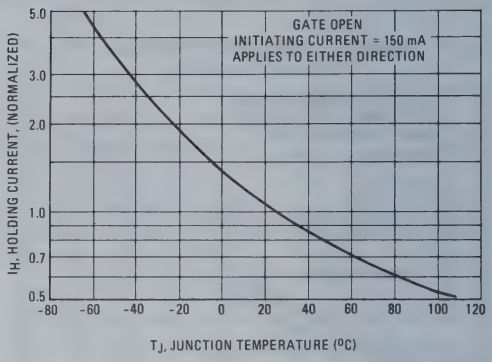
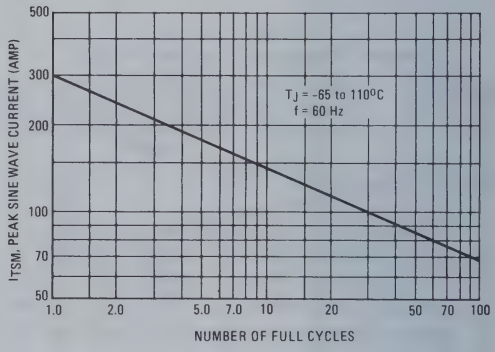
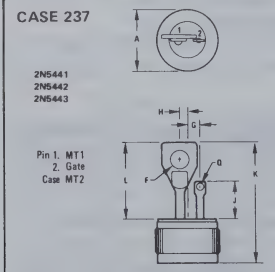


FIGURE 8 – MAXIMUM ALLOWABLE SURGE CURRENT



CASE 237



2N5441
2N5442
2N5443

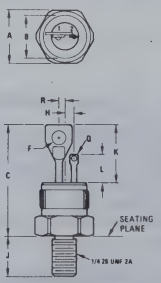
Pin 1. MT1
2. Gate
Case MT2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.73	12.83	0.501	0.505
F	–	4.06	–	0.160
G	2.16	2.41	0.085	0.095
H	1.52	1.78	0.060	0.070
J	6.99	7.75	0.275	0.305
K	–	26.67	–	1.050
L	–	17.02	–	0.670
Q	1.40	1.65	0.055	0.065

NOTE
1. DIM "G" & "H" TO BE MEASURED AT CAN

CASE 237-01

CASE 238



2N5444
2N5445
2N5446

Pin 1. MT1
2. Gate
Stud MT2

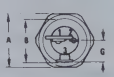
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.00	14.20	0.551	0.559
B	12.73	12.83	0.501	0.505
C	–	30.23	–	1.190
F	–	4.06	–	0.160
H	2.16	2.41	0.085	0.095
J	10.67	11.56	0.420	0.455
K	–	17.02	–	0.670
L	6.99	7.75	0.275	0.305
Q	1.40	1.65	0.055	0.065
R	1.52	1.78	0.060	0.070

NOTE
1. DIM "H" & "R" TO BE MEASURED AT CAN.

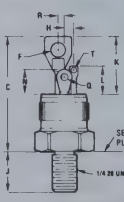
CASE 239

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.00	14.20	0.551	0.559
B	12.73	12.83	0.501	0.505
C	–	32.51	–	1.280
F	–	4.06	–	0.160
G	–	6.48	–	0.255
H	2.16	2.41	0.085	0.095
J	10.67	11.56	0.420	0.455
K	–	17.02	–	0.670
L	6.99	7.75	0.275	0.305
N	6.48	6.99	0.255	0.275
Q	3.43	3.81	0.135	0.150
R	1.52	1.78	0.060	0.070
T	1.40	1.65	0.055	0.065

MAC40688
MAC40689
MAC40690



NOTE
1. DIM "G", "H" & "R" TO BE MEASURED AT CAN



Pin 1. MT1
2. Gate
3. MT2
Stud Isolated

2N5457 (SILICON)
2N5458
2N5459

Silicon N-channel junction field-effect transistors depletion mode (Type A) designed for general-purpose audio and switching applications.



CASE 29 (5)
(TO-92)

Drain and source may be interchanged.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A= 25°C Derate above 25°C	P_D (2)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (2)	135	°C
Storage Temperature Range	T_{stg} (2)	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		BV_{GSS}	25	—	—	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	—	—	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)			—	—	200	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5457	$V_{GS(off)}$	0.5	—	6.0	Vdc
	2N5458		1.0	—	7.0	
	2N5459		2.0	—	8.0	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 100 μAdc)	2N5457	V_{GS}	—	2.5	—	Vdc
(V_{DS} = 15 Vdc, I_D = 200 μAdc)	2N5458		—	3.5	—	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	2N5459		—	4.5	—	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5457	I_{DSS}	1.0	3.0	5.0	mAdc
	2N5458		2.0	6.0	9.0	
	2N5459		4.0	9.0	16	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	2N5457	$\lvert y_{fs} \rvert$	1000	3000	5000	μmhos
	2N5458		1500	4000	5500	
	2N5459		2000	4500	6000	
Output Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)		$\lvert y_{os} \rvert$	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	—	1.5	3.0	pF

(1) Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%

(2) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

2N5460 (SILICON) thru 2N5465

P-channel depletion mode (Type A) junction field-effect transistors designed for use in general-purpose amplifier applications.



CASE 29(7)
(TO-92)

PIN 1. SOURCE
2. DRAIN
3. GATE

MAXIMUM RATINGS

Rating	Symbol	2N5460 2N5461 2N5462	2N5463 2N5464 2N5465	Unit
Drain-Gate Voltage	V_{DG}	40	60	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	60	Vdc
Forward Gate Current	$I_{G(f)}$	10		mAdc
Total Device Dissipation @ T_A = 25°C	P_D (1)	310		mW
Derate above 25°C		2.82		mW/°C
Storage Temperature Range	T_{stg} (1)	-65 to +150		°C
Operating Junction Temperature Range	T_J (1)	-65 to +135		°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	2N5460, 2N5461, 2N5462	$V_{(BR)GSS}$	40	-	-	Vdc
	2N5463, 2N5464, 2N5465		60	-	-	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	2N5460, 2N5463	$V_{GS(off)}$	0.75	-	6.0	Vdc
	2N5461, 2N5464		1.0	-	7.5	
	2N5462, 2N5465		1.8	-	9.0	
Gate Reverse Current		I_{GSS}				nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0)	2N5460, 2N5461, 2N5462		-	-	5.0	
(V_{GS} = 30 Vdc, V_{DS} = 0)	2N5463, 2N5464, 2N5465		-	-	5.0	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	2N5460, 2N5461, 2N5462		-	-	1.0	μAdc
(V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 100°C)	2N5463, 2N5464, 2N5465		-	-	1.0	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5460, 2N5463	I_{DSS}	1.0	-	5.0	mAdc
	2N5461, 2N5464		2.0	-	9.0	
	2N5462, 2N5465		4.0	-	16	
Gate-Source Voltage		V_{GS}				Vdc
(V_{DS} = 15 Vdc, I_D = 0.1 mAdc)	2N5460, 2N5463		0.5	-	4.0	
(V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	2N5461, 2N5464		0.8	-	4.5	
(V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	2N5462, 2N5465		1.5	-	6.0	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5460, 2N5463	$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
	2N5461, 2N5464		1500	-	5000	
	2N5462, 2N5465		2000	-	6000	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os} \rvert$	-	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	5.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	1.0	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	60	115	$nV/\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 – 2N5460 and 2N5463

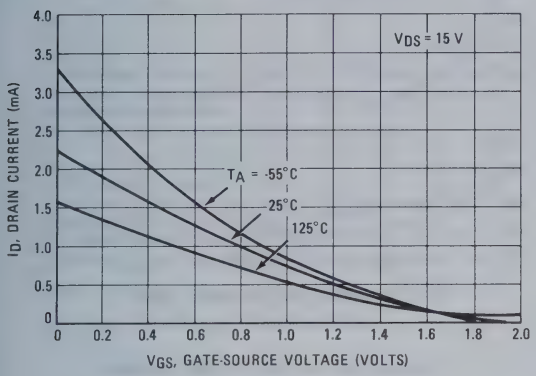


FIGURE 2 – 2N5461 and 2N5464

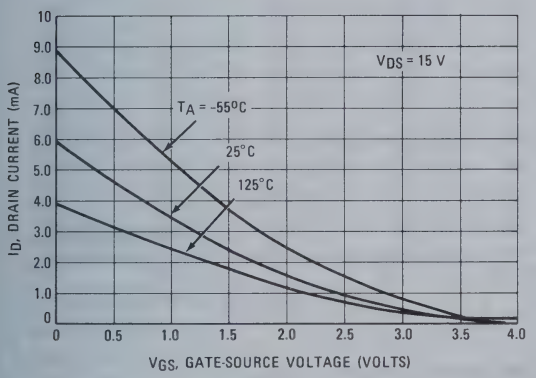
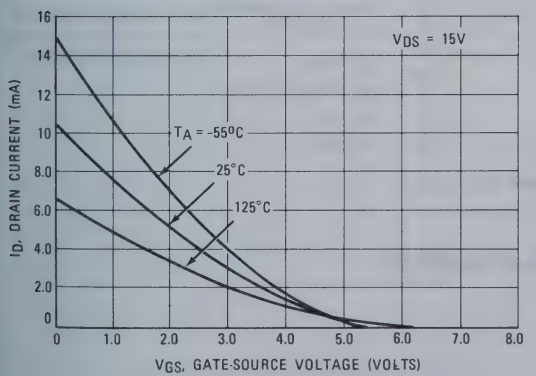


FIGURE 3 – 2N5462 and 2N5465



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 – 2N5460 and 2N5463

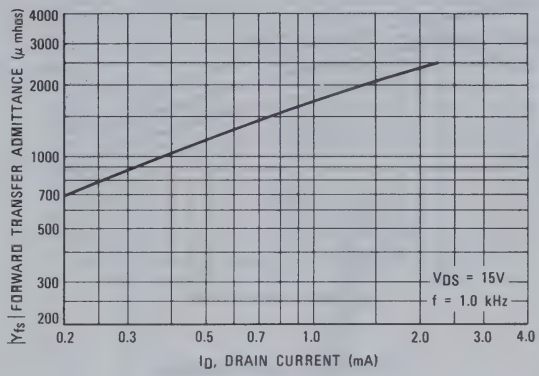


FIGURE 5 – 2N5461 and 2N5464

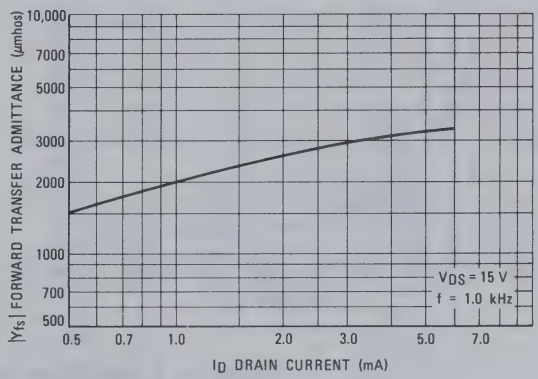


FIGURE 6 – 2N5462 and 2N5465

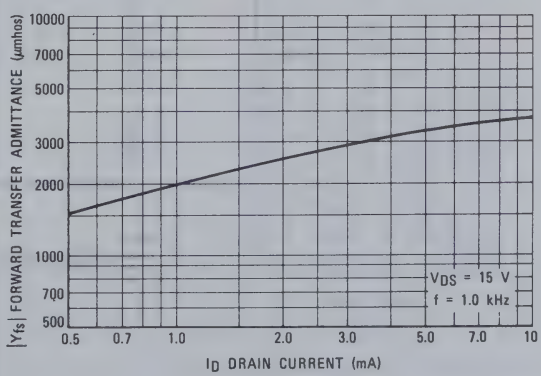


FIGURE 7 – OUTPUT RESISTANCE VERSUS DRAIN CURRENT

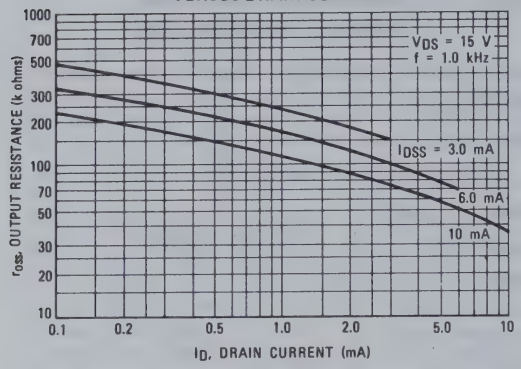


FIGURE 8 – CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE

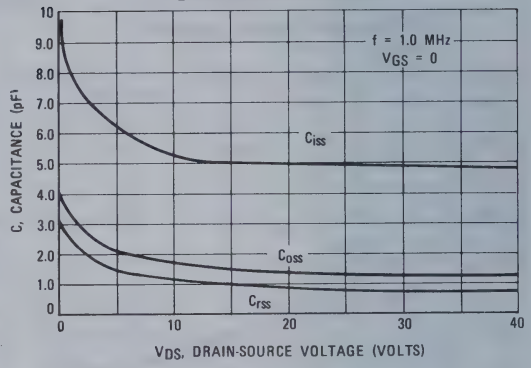


FIGURE 9 – NOISE FIGURE VERSUS FREQUENCY

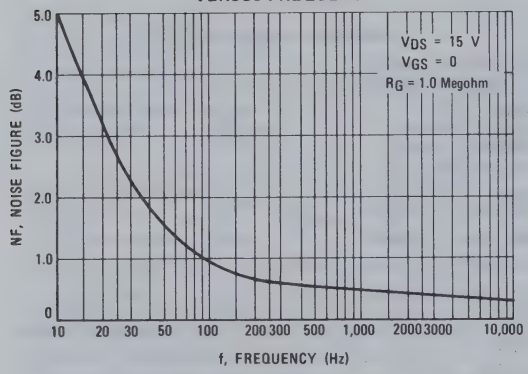


FIGURE 10 – NOISE FIGURE VERSUS SOURCE RESISTANCE

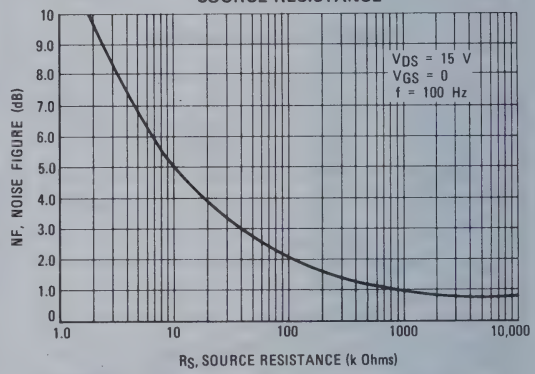
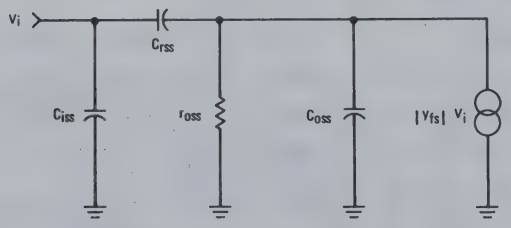


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}{}^{*} + 1/r_{oss}$

$y_{fs} = y_{fs}\ |$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5471 (SILICON)
thru
2N5476

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion mode Junction Field-Effect Transistors designed for general-purpose amplifier and switching applications.

- High Gate-Source Breakdown Voltage –
  $V_{(BR)GSS}$ = 40 Vdc (Min) for All Types
- High DC Input Resistance –
  I_{GSS} = 100 pAdc (Max) @ V_{GS} = 10 Vdc
- Low Reverse Transfer Capacitance –
  C_{rss} = 1.0 pF (Max) @ V_{DS} = -15 Vdc
- Tight I_{DSS} Range for Easier Circuit Design
- Drain and Source Interchangeable

P-CHANNEL

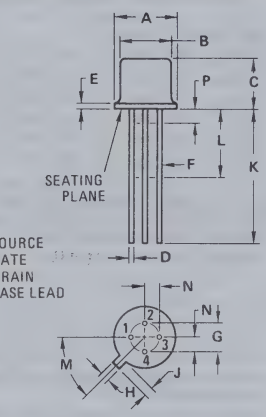
JUNCTION FIELD-EFFECT TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Channel Temperature Range	$T_{channel}$	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. CASE LEAD

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-05
TO-72

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate-Source Cutoff Voltage		$V_{GS(off)}$			Vdc
(V_{DS} = -15 Vdc, I_D = -10 nAdc)	2N5471		0.5	4.0	
	2N5472		0.7	4.0	
	2N5473		0.9	6.0	
	2N5474		1.2	7.0	
	2N5475		1.5	8.0	
	2N5476		2.0	9.0	
Reverse Gate Current		I_{GSS}			nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0)			–	0.1	
(V_{GS} = 20 Vdc, V_{DS} = 0)			–	0.5	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			–	1.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1)		I_{DSS}			mAdc
(V_{DS} = -15 Vdc, V_{GS} = 0)	2N5471		0.02	0.06	
	2N5472		0.05	0.12	
	2N5473		0.10	0.25	
	2N5474		0.20	0.50	
	2N5475		0.40	1.0	
	2N5476		0.80	2.0	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = -15 Vdc, I_D = 2.0 μAdc)	2N5471		0.5	3.0	
(V_{DS} = -15 Vdc, I_D = 5.0 μAdc)	2N5472		0.7	3.5	
(V_{DS} = -15 Vdc, I_D = 10 μAdc)	2N5473		0.9	4.5	
(V_{DS} = -15 Vdc, I_D = 20 μAdc)	2N5474		1.2	6.0	
(V_{DS} = -15 Vdc, I_D = 40 μAdc)	2N5475		1.5	7.5	
(V_{DS} = -15 Vdc, I_D = 80 μAdc)	2N5476		2.0	8.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (1)		$\|y_{fs}\|$			μmhos
(V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5471		60	180	
	2N5472		90	225	
	2N5473		120	300	
	2N5474		160	400	
	2N5475		200	500	
	2N5476		260	650	
Output Admittance (1)		$\|y_{os}\|$			μmhos
(V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5471		–	1.0	
	2N5472		–	1.0	
	2N5473		–	2.5	
	2N5474		–	2.5	
	2N5475		–	5.0	
	2N5476		–	10	
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, 140 kHz ≤ f ≤ 1.0 MHz)		C_{iss}	–	5.0	pF
Reverse Transfer Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, 140 kHz ≤ f ≤ 1.0 MHz)		C_{rss}	–	1.0	pF
Common-Source Noise Figure (V_{DS} = -15 Vdc, V_{GS} = 0, R_S = 1.0 Megohm, f = 1.0 kHz, BW = 1.0 Hz)		NF	–	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)		e_n	–	110	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

TYPICAL SMALL-SIGNAL CHARACTERISTICS

($T_{channel}$ = 25°C)

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

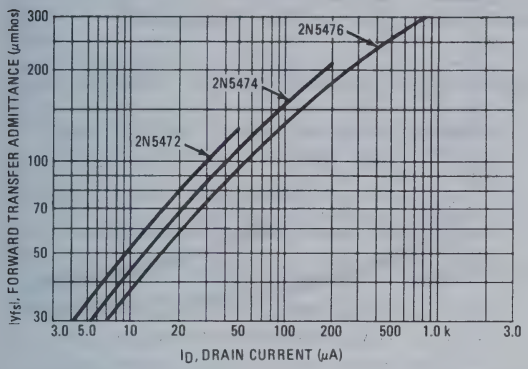
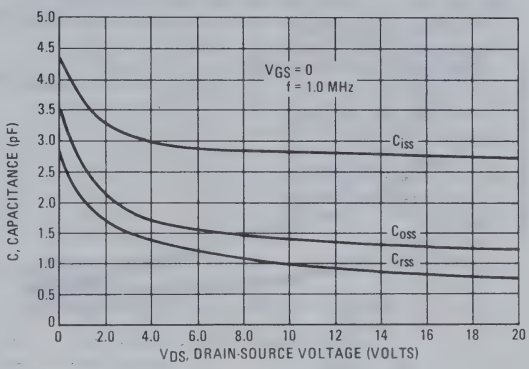


FIGURE 2 – CAPACITANCE



TYPICAL NOISE FIGURE

FIGURE 3 – EFFECTS OF FREQUENCY

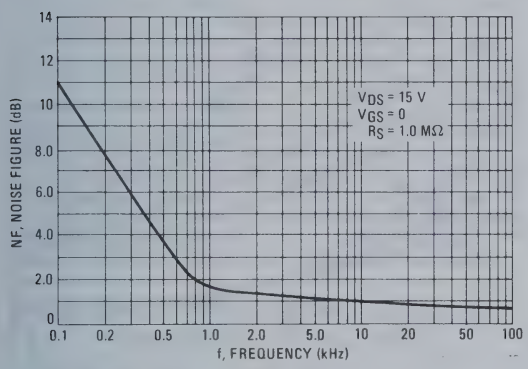


FIGURE 4 – EFFECTS OF SOURCE RESISTANCE

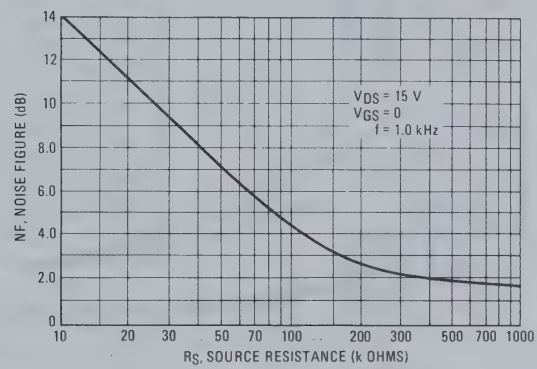
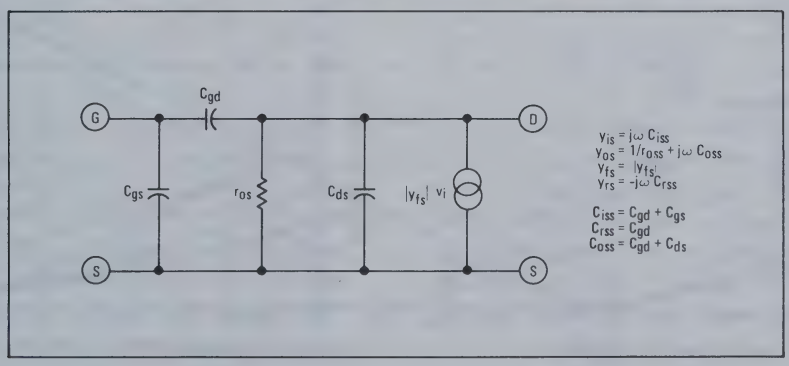


FIGURE 5 – LOW FREQUENCY CIRCUIT MODEL



TYPICAL LIMIT TRANSFER CHARACTERISTICS

(TEMPERATURES NOTED ARE $T_{channel}$)

FIGURE 6 – 2N5471

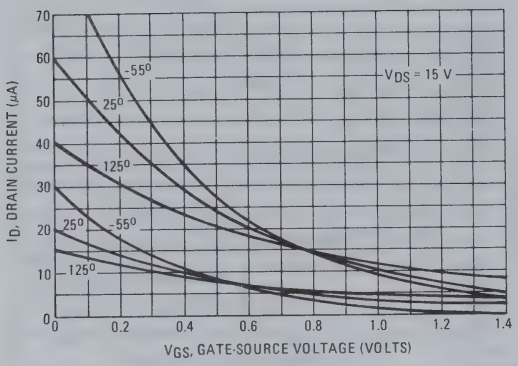


FIGURE 7 – 2N5472

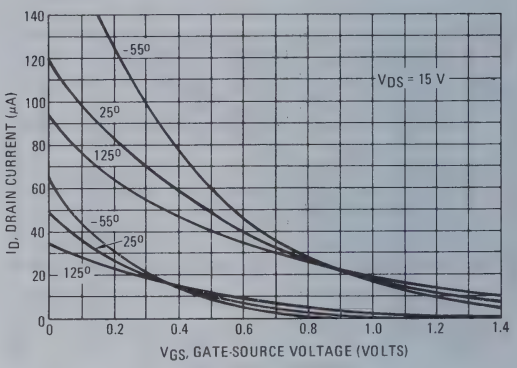


FIGURE 8 – 2N5473

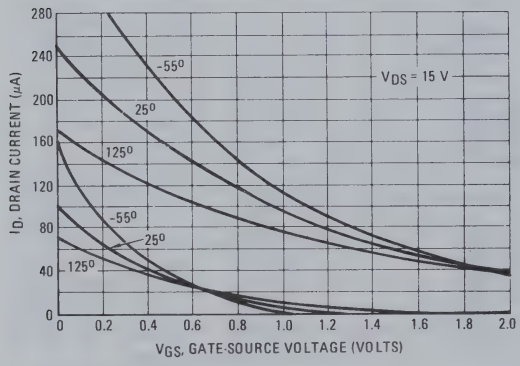


FIGURE 9 – 2N5474

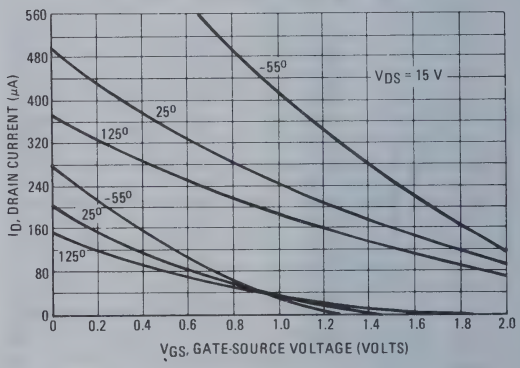


FIGURE 10 – 2N5475

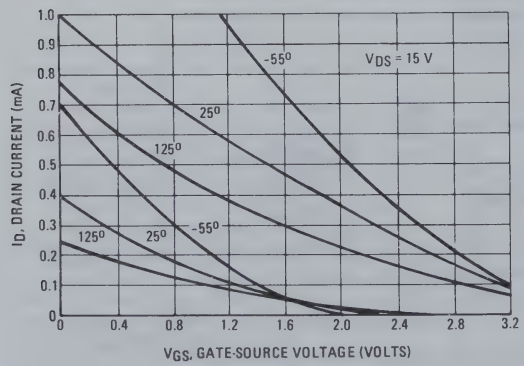
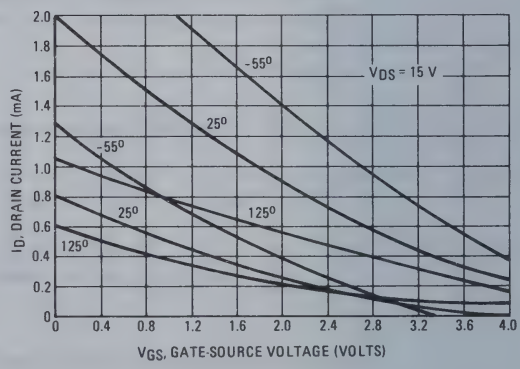


FIGURE 11 – 2N5476



2N5477 (SILICON)
thru
2N5480

MEDIUM-POWER NPN SILICON TRANSISTORS

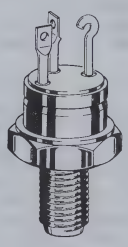
. . . designed for switching and wide-band amplifier applications.

- Low Collector Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Collector Common to Case

7 AMPERE POWER TRANSISTORS

NPN SILICON

80-100 VOLTS
60 WATTS



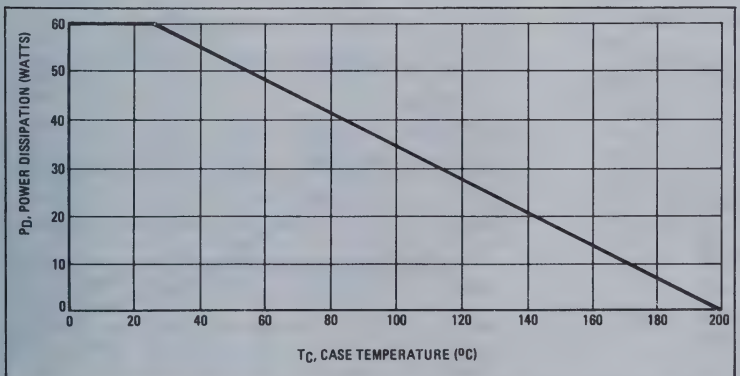
MAXIMUM RATINGS

Rating	Symbol	2N5477 2N5478	2N5479 2N5480	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current - Continuous	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	60		Watts
Derate above 25°C		343		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

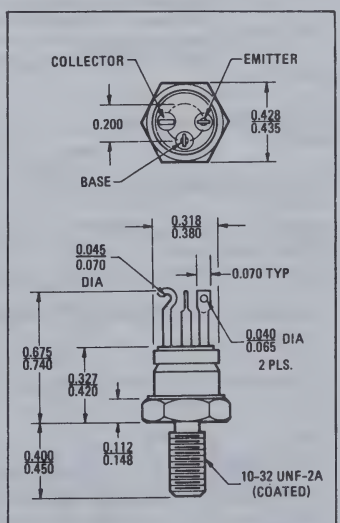
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



CASE 160 A
(TO-59)

Collector Common
To Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	2N5477, 2N5478 2N5479, 2N5480	-	$V_{CEO(sus)}$	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5477, 2N5478	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5479, 2N5480			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5477, 2N5478	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5479, 2N5480			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5477, 2N5478			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5479, 2N5480			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480	8	h_{FE}	30 60	- -	-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480			30 60	120 240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480			20 40	- -	
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)		t_f	-	200	ns

(1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

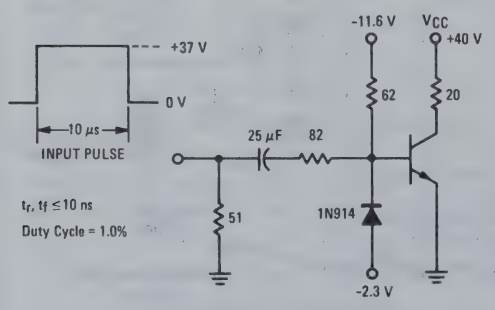


FIGURE 3 — TURN-ON TIME

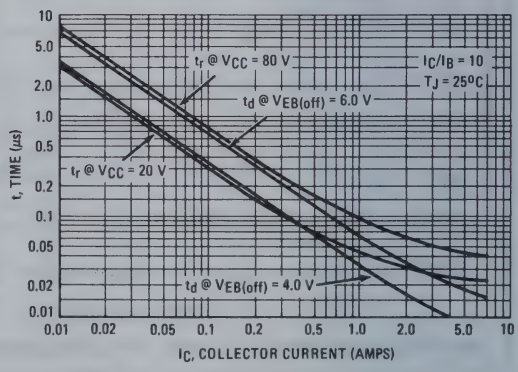


FIGURE 4 – THERMAL RESPONSE

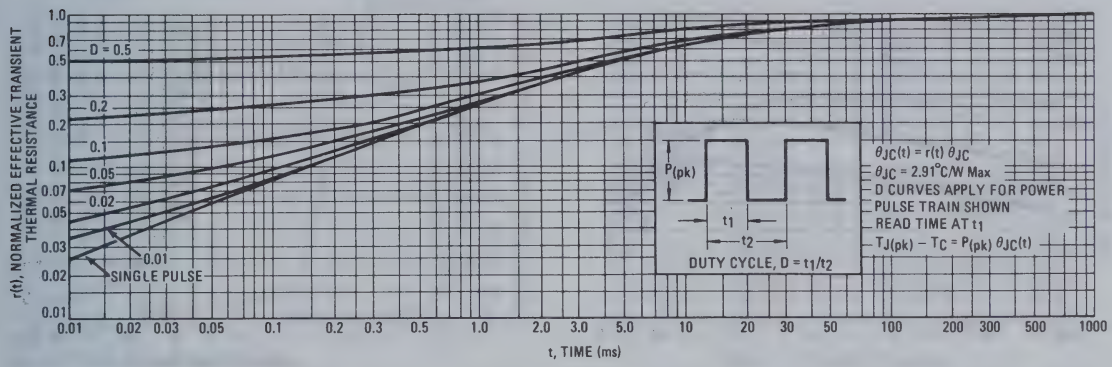
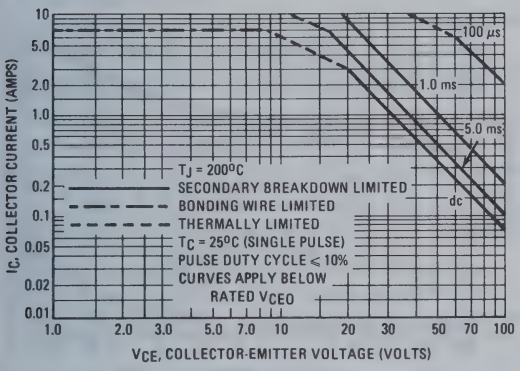


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

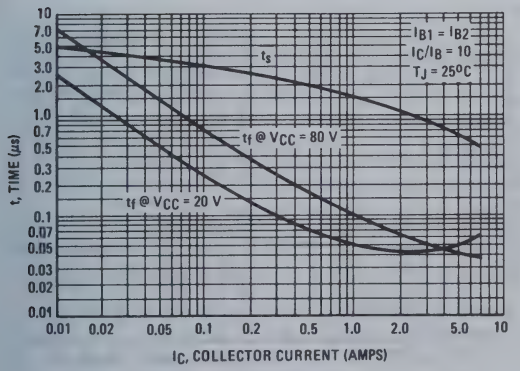


FIGURE 7 – CAPACITANCE versus VOLTAGE

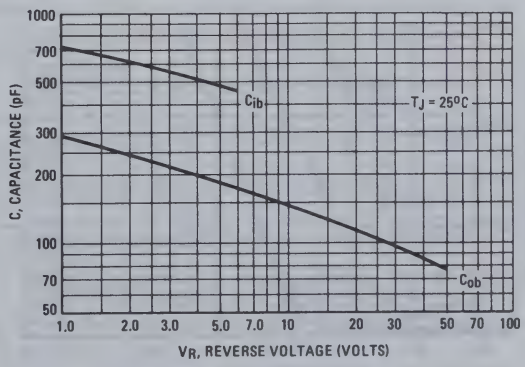


FIGURE 8 – DC CURRENT GAIN

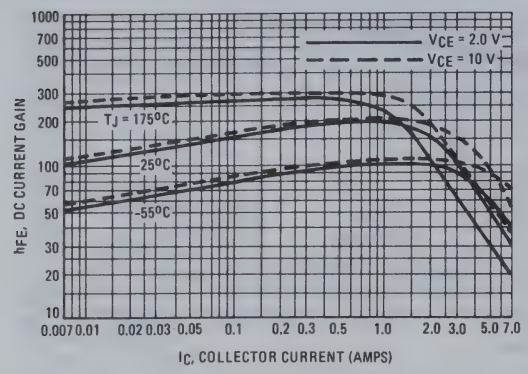


FIGURE 9 – COLLECTOR SATURATION REGION

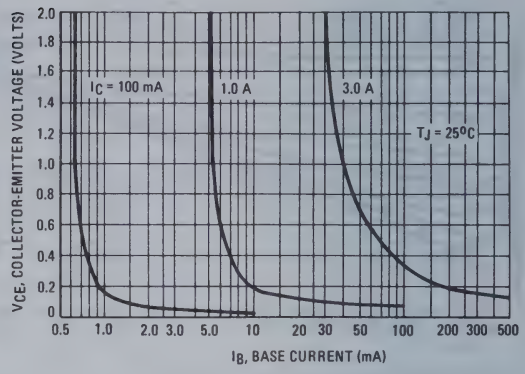


FIGURE 10 – EFFECTS OF BASE EMITTER RESISTANCE

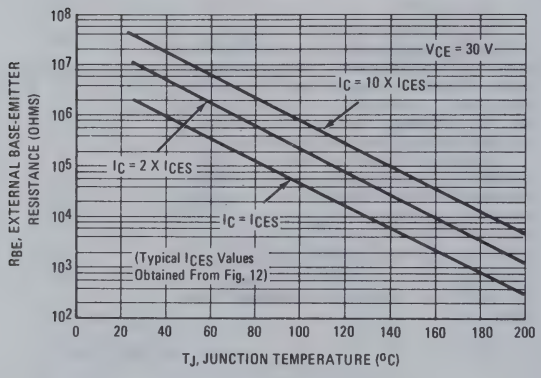


FIGURE 11 – "ON" VOLTAGES

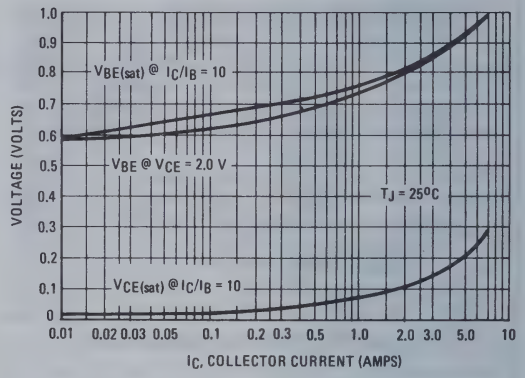


FIGURE 12 – COLLECTOR CUT-OFF REGION

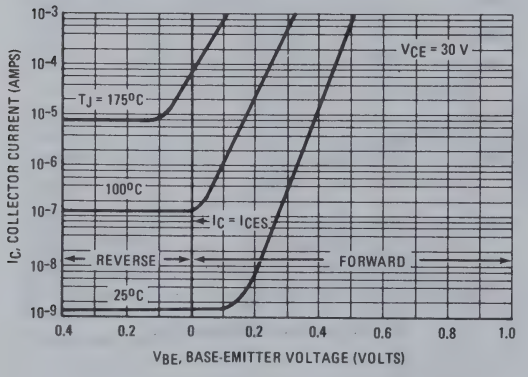
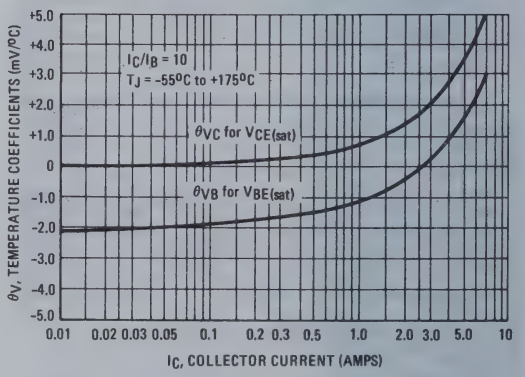


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5484 (SILICON) thru 2N5486

N-channel depletion mode (Type A) junction field-effect transistors designed for VHF/UHF amplifier applications.



CASE 29 (5)
(TO-92)

Pin 1. Drain
2. Source
3. Gate

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Drain Current	I_D	30	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-65 to +150	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, $T_J = -65$ to +150°C, $\theta_{JC} = 125°$ C/W.

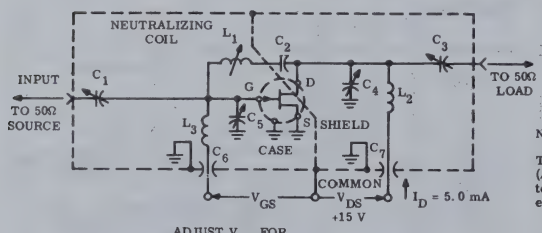
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -1.0$ μAdc, $V_{DS} = 0$)		$V_{(BR)GSS}$	25	-	-	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	2N5484	$V_{GS(off)}$	0.3	-	3.0	Vdc
	2N5485		0.5	-	4.0	
	2N5486		2.0	-	6.0	
Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-	1.0	nAdc
($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)			-	-	0.2	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N5484	I_{DSS}	1.0	-	5.0	mAdc
	2N5485		4.0	-	10	
	2N5486		8.0	-	20	

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance		$\|y_{fs}\|$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484		3000	-	6000	
	2N5485		3500	-	7000	
	2N5486		4000	-	8000	
Forward Transconductance		$Re(y_{fs})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		2500	-	-	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485		3000	-	-	
	2N5486		3500	-	-	
Output Admittance		$\|y_{os}\|$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484		-	-	50	
	2N5485		-	-	60	
	2N5486		-	-	75	
Output Conductance		$Re(y_{os})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		-	-	75	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485, 2N5486		-	-	100	
Input Conductance		$Re(y_{is})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		-	-	100	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485, 2N5486		-	-	1000	
Input Capacitance		C_{iss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	5.0	
Reverse Transfer Capacitance		C_{rss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	1.0	
Output Capacitance		C_{oss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	2.0	
Common-Source Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	All Types		-	-	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5484		-	-	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 200 MHz)	2N5484		-	4.0	-	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5485, 2N5486		-	-	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 400 MHz)	2N5485, 2N5486		-	-	4.0	
Insertion Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	-	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		-	14	-	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5485, 2N5486		18	-	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5485, 2N5486		10	-	20	

FIGURE 1 – 100 MHz AND 400 MHz NEUTRALIZED AMPLIFIER



ADJUST V_{GS} FOR
I_D = 5.0 mA
V_{GS} < 0 VOLTS

NOTE:

The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE 100 MHz	VALUE 400 MHz
C_1	1-12 pF	0.8-8.0 pF
C_2	1000 pF	27 pF
C_3	1-12 pF	0.8-8.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.25 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

* L_1 17 turns (approximately - depending upon circuit layout), AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4 1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I. D. (AIR CORE).

L_3 3 1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I. D. (AIR CORE).

** L_1 6 turns (approximately - depending upon circuit layout), AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L_2 1 turn, AWG #16 enameled copper wire, 3/8" I. D. (AIR CORE).

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I. D. (AIR CORE).

2N5550 (SILICON)
2N5551

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier applications.

- High Voltage Ratings — BV_{CEO} = 140 and 160 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.25 V (max) @ I_C = 50 mA, 2N5550
  = 0.20 V (max) @ I_C = 50 mA, 2N5551
- Current Gain Specified from 1.0 mAdc to 50 mAdc

HIGH VOLTAGE
NPN SILICON AMPLIFIER TRANSISTORS



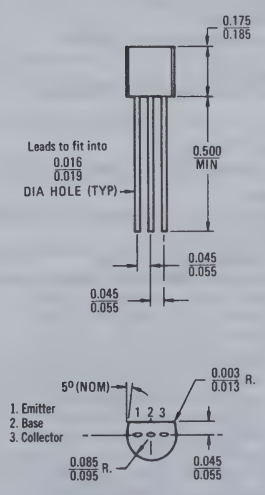
*MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CB}	160	180	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	−55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



CASE 29-02
(TO-92)

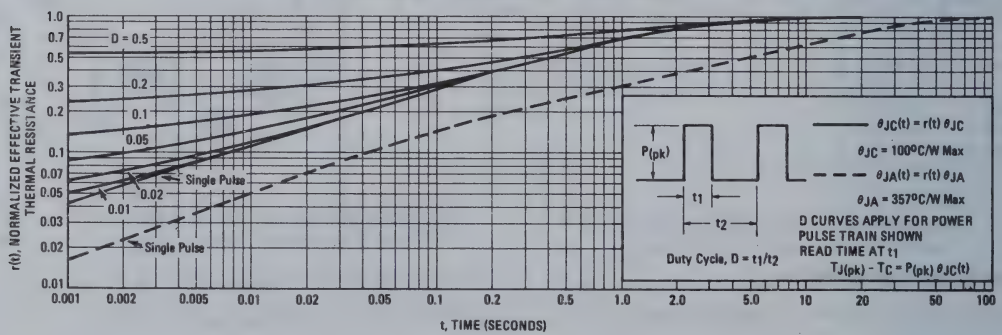
* Indicates JEDEC Registered Data

* **ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CEO}			Vdc
(I_C = 1.0 mAdc, I_B = 0)	2N5550		140	–	
	2N5551		160	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N5550		160	–	
	2N5551		180	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			6.0	–	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5550		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	2N5551		–	50	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	2N5550		–	100	μAdc
(V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	2N5551		–	50	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 4.0 Vdc, I_C = 0)			–	50	
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	–	
	2N5551		80	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	250	
	2N5551		80	250	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5550		20	–	
	2N5551		30	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		–	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		–	0.25	
	2N5551		–	0.20	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		–	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		–	1.2	
	2N5551		–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)			100	300	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)			–	6.0	
Input Capacitance		C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550		–	30	
	2N5551		–	20	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			50	200	
Noise Figure		NF			dB
(I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm,	2N5550		–	10	
f = 10 Hz to 15.7 kHz)	2N5551		–	8.0	

*Indicates JEDEC Registered Data
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

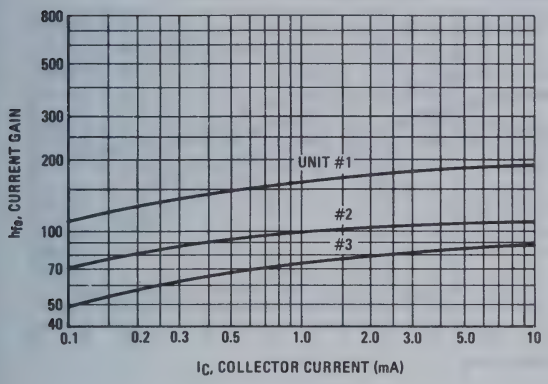


FIGURE 3 – OUTPUT ADMITTANCE

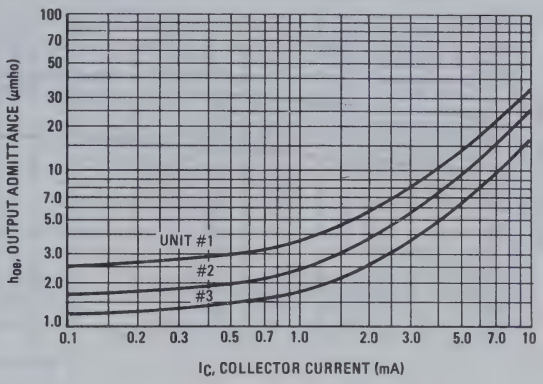


FIGURE 4 – INPUT IMPEDANCE

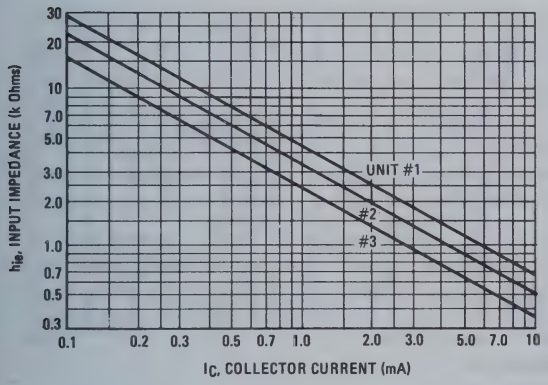


FIGURE 5 – VOLTAGE FEEDBACK RATIO

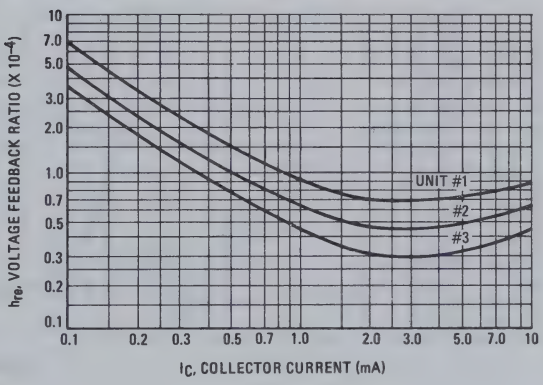
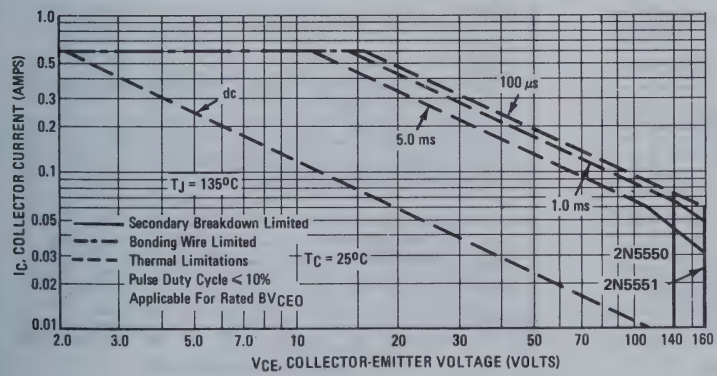


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 135°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

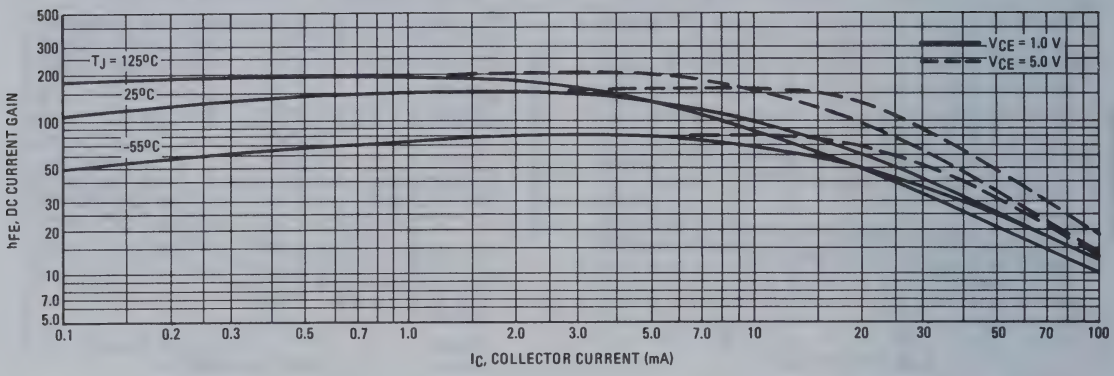


FIGURE 8 – COLLECTOR SATURATION REGION

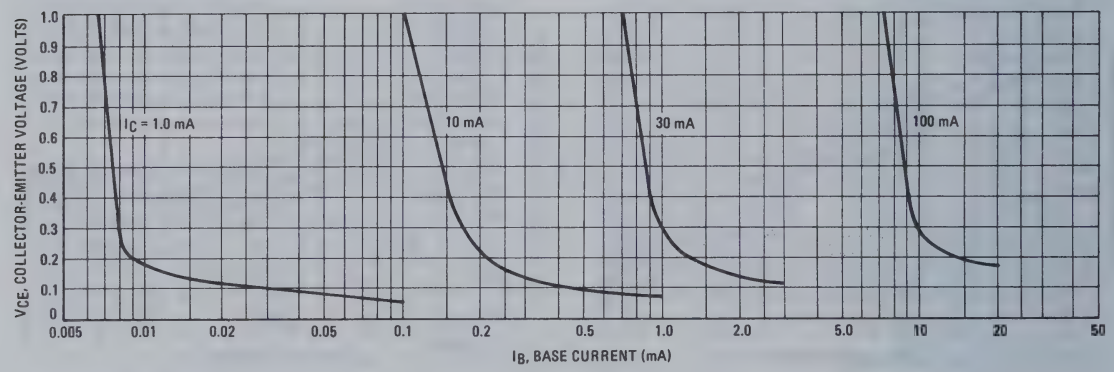


FIGURE 9 – COLLECTOR CUT-OFF REGION

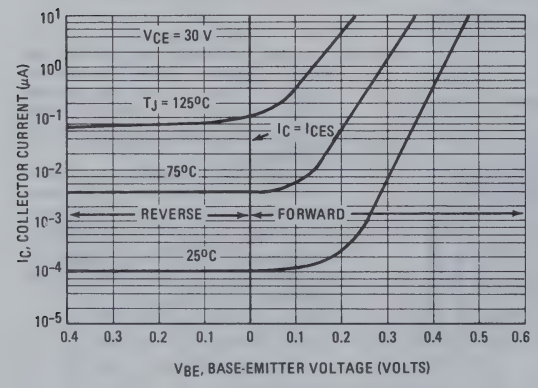


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

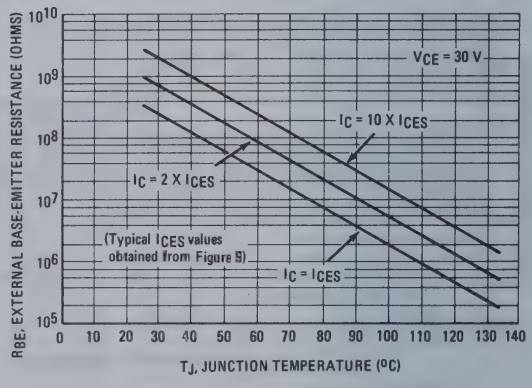


FIGURE 11 – "ON" VOLTAGES

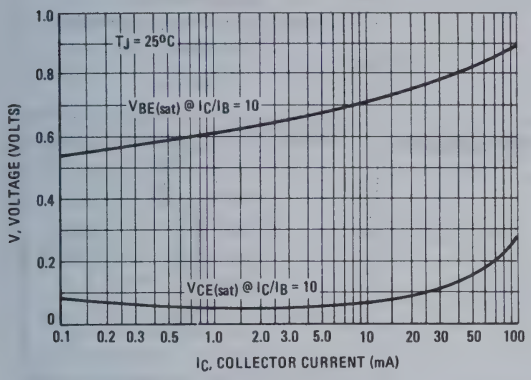


FIGURE 12 – TEMPERATURE COEFFICIENTS

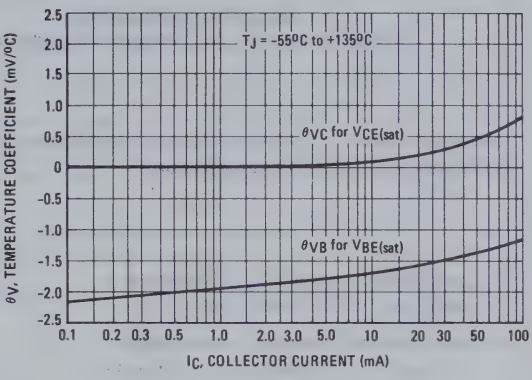


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

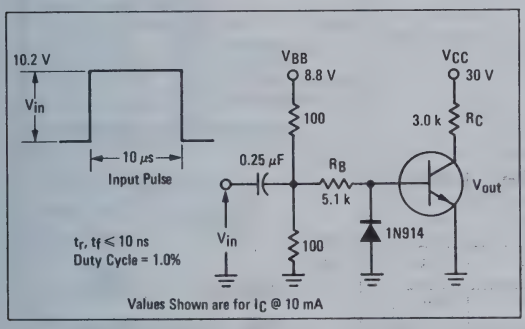


FIGURE 14 – CAPACITANCES

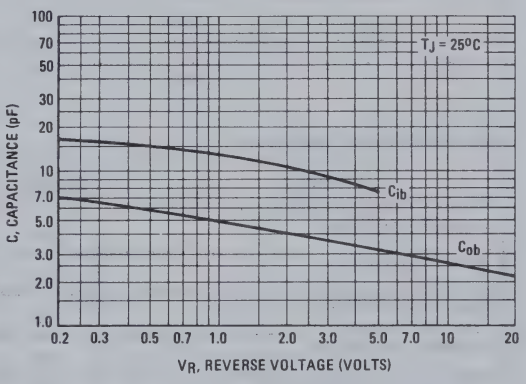


FIGURE 15 – TURN-ON TIME

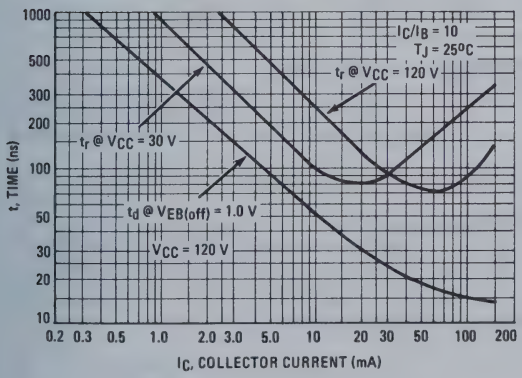
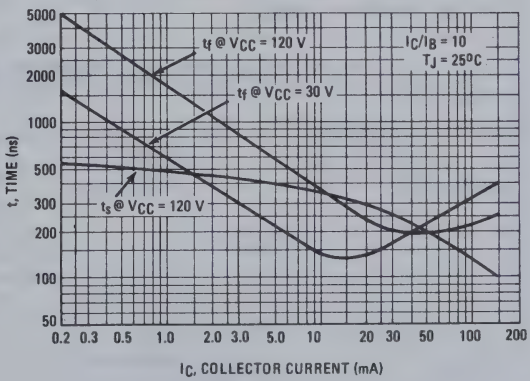


FIGURE 16 – TURN-OFF TIME



2N5555 (SILICON)

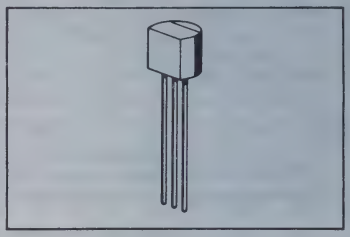
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

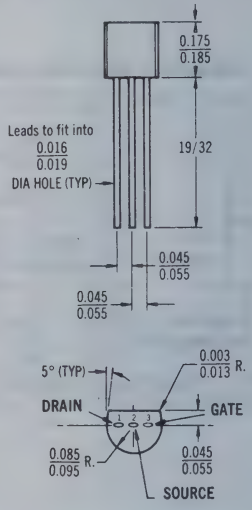
Depletion Mode (Type A) Junction Field-Effect Transistor designed for high-speed switching applications.

- Low Drain-Source "On" Resistance — $r_{ds(on)}$ = 150 Ohms (Max)
- Low Reverse Transfer Capacitance — C_{rss} = 1.2 pF (Max) @ f = 1.0 MHz
- Fast Turn-On Time — $t_{(on)}$ = 10 ns (Max)

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

TYPE A





CASE 29 (5)
(TO-92)

Drain and Source may be Interchanged.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	$P_{(1)}$	310 2.82	mW mW/°C
Operating Junction Temperature Range	$T_{(1)}$	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

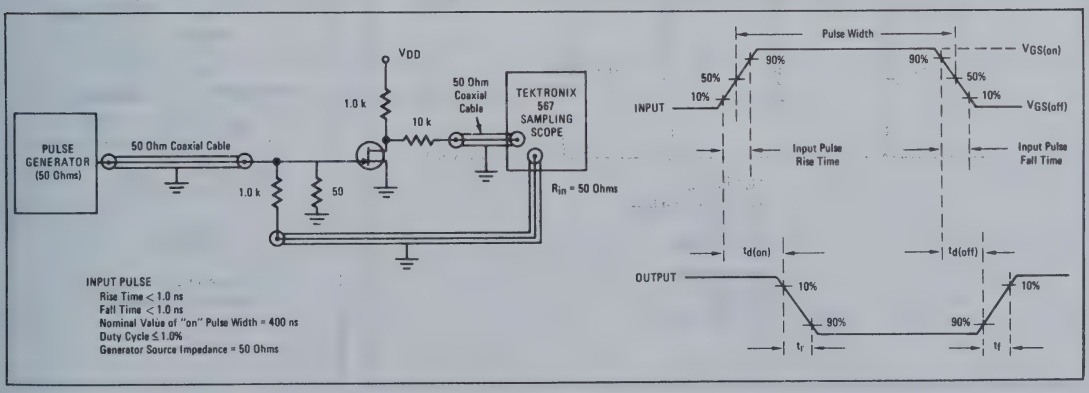
2N5555 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	-	1.0	nAdc
Drain Cutoff Current (V_{DS} = 12 Vdc, V_{GS} = 10 Vdc)	$I_{D(off)}$	-	10	nAdc
(V_{DS} = 12 Vdc, V_{GS} = 10 Vdc, T_A = 100°C)		-	2.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current [1] (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	15	-	mAdc
Gate-Source Forward Voltage ($I_{G(f)}$ = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	-	1.0	Vdc
Drain-Source "ON" Voltage (I_D = 7.0 mAdc, V_{GS} = 0)	$V_{DS(on)}$	-	1.5	Vdc
Static Drain-Source "ON" Resistance (I_D = 0.1 mAdc, V_{GS} = 0)	$r_{DS(on)}$	-	150	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	150	Ohms
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	-	1.2	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(on)}$	-	5.0	ns
Rise Time	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc) (See Figure 1)	t_r	-	5.0	ns
Turn-Off Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(off)}$	-	15	ns
Fall Time	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc) (See Figure 1)	t_f	-	10	ns

[1] Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N5556 (SILICON) thru 2N5558

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) devices designed for low-noise amplifier applications.

- Low Noise Figure – NF = 1.0 dB (Max) @ 100 Hz
- Low Gate Leakage Current – I_{GSS} = 0.1 nAdc (Max)
- Low Input Capacitance – C_{iss} = 6.0 pF (Max)

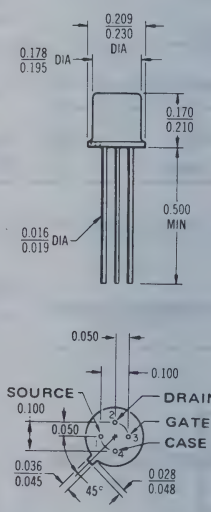
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

TYPE A



MAXIMUM RATINGS

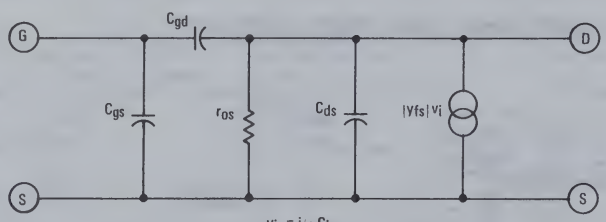
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C



CASE 20(1)
(TO-72)

Drain and Source may be interchanged.

FIGURE 1 – EQUIVALENT LOW FREQUENCY CIRCUIT



$Y_{is} = j\omega C_{iss}$
$Y_{os} = 1/r_{oss} + j\omega C_{oss}$
$Y_{fs} = |Y_{fs}|$
$Y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	2N5556	$V_{GS(off)}$	0.2	-	4.0	Vdc
	2N5557		0.8	-	5.0	
	2N5558		1.5	-	6.0	
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	-	-	-0.1	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	-100	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current [1] (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5556	I_{DSS}	0.5	-	2.5	mAdc
	2N5557		2.0	-	5.0	
	2N5558		4.0		10	
DYNAMIC CHARACTERISTICS						
Forward Transadmittance [1] (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{fs}\|$	1500	3500	6500	μmhos
Output Admittance [1] (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	-	-	20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	1.2	3.0	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 500 k ohms, f = 10 Hz, BW = 1.0 Hz)		NF	-	-	1.0	dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 100 k ohms, f = 100 Hz, BW = 1.0 Hz)			-	-	1.0	
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, BW = 1.0 Hz)		e_n	-	20	35	$nV/\sqrt{Hz}$
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)			-	10	20	

[1] Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%.

2N5571 thru 2N5574 (SILICON)
2N6145 thru 2N6147
MAC40797, MAC40798

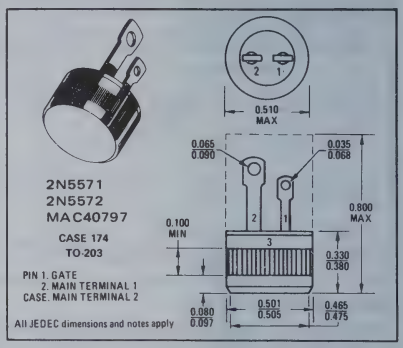


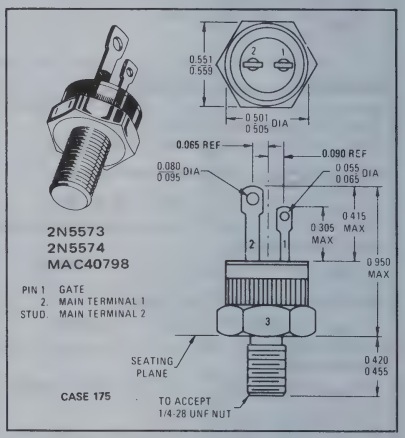
SILICON BIDIRECTIONAL THYRISTORS

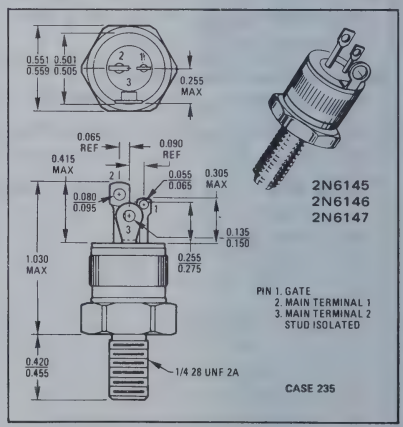
. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- All Diffused and Passivated Junctions for Greater Stability
- Pressfit, Stud and Isolated Stud Packages
- Gate Triggering Guaranteed In All 4 Quadrants

TRIACS (THYRISTORS)
15 AMPERES RMS
200-600 VOLTS







MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage (1) (T_J = -65 to +125°C) 1/2 Sine Wave 50 to 60 Hz, Gate Open	V_{DRM} and V_{RRM}		Volts
2N5571, 2N5573, 2N6145		200	
2N5572, 2N5574, 2N6146		400	
MAC40797, MAC40798, 2N6147		600	
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (T_C = -65 to +80°C)	$I_{T(RMS)}$	15	Amp
(T_C = +85°C)		10	
*Peak Surge Current (One Full cycle of surge current at 60 Hz, preceeded and followed by 15 A current, T_C = +80°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_C = -65 to +80°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power (2) (T_C = +80°C, Pulse Width = 2.0 μs)	P_{GM}	20	Watts
*Average Gate Power (T_C = +80°C, Pulse Width = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-65 to +100	°C
*Storage Temperature Range	T_{stg}	-65 to +150	°C
*Stud Torque 2N5573, 2N5574 2N6145, 2N6146, 2N6147	–	30	in.lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.0	°C/W

*Indicates JEDEC Registered Data.

(1) Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) 2N5571 thru 2N5574, P_{GM} Rating = 16 Watts.

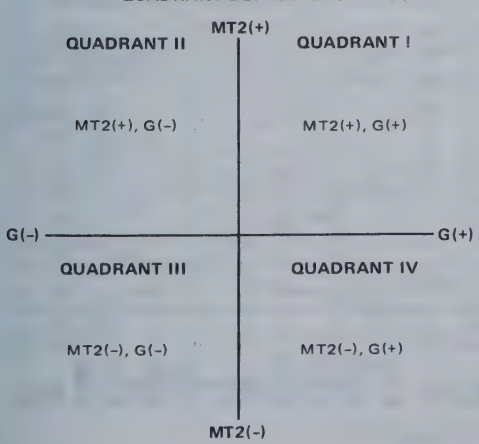
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_C = 100°C	I_{DRM}	 –	 –	 2.0	mA
*On-State Voltage (Either Direction) I_{TM} = 21 A Peak, Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤2.0%	V_{TM}	 –	 1.3	 1.8	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 12 Vdc, R_L = 30 ohms MT2 (+), G(+); MT2(–), G(–) MT2 (+), G(–); MT2(–), G(+) *MT2 (+), G(+); MT2(–), G(–) T_C = -65°C *MT2 (+), G(–); MT2(–), G(+) T_C = -65°C	I_{GT}	 – – – –	 – – – –	 50 80 150 200	mA
Gate Trigger Voltage, Continuous dc (All Quadrants) Main Terminal Voltage = 12 Vdc, R_L = 30 ohms T_C = 25°C *T_C = -65°C *Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_C = +100°C	V_{GT}	 – – 0.2	 – – –	 2.5 4.0 –	Volts
Holding Current Main Terminal Voltage = 12 Vdc, Gate Open Initiating Current = 500 mA T_C = 25°C *T_C = -65°C	I_H	 – –	 – –	 75 300	mA
*Turn-On Time Rated V_{DRM}, I_{TM} = 21 A Peak, I_{GT} = 160 mA, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	t_{gt}	 –	 1.0	 2.0	μs
*Critical Rate-of-Rise of Commutation Voltage Rated V_{DRM}, I_{TM} = 21 A Peak, Commutating di/dt = 8 A/ms, gate unenergized T_C = 80°C 2N5571 thru 2N5574, MAC40797, MAC40798 T_C = 75°C 2N6145 thru 2N6147	dv/dt	 2.0 2.0	 10 10	 – –	V/μs
*Critical Rate-of-Rise of Off-State Voltage Rated V_{DRM}, Exponential Voltage Rise, Gate Open, T_C = 100°C: 2N5571, 2N5573, 2N6145 2N5572, 2N5574, 2N6146 MAC40797, MAC40798, 2N6147	dv/dt	 30 20 10	 150 100 75	 – – –	V/μs

*Indicates JEDEC Registered Data.

(1)All Voltage polarity reference to main terminal 1.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient = 0.02%/°C Typ			

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

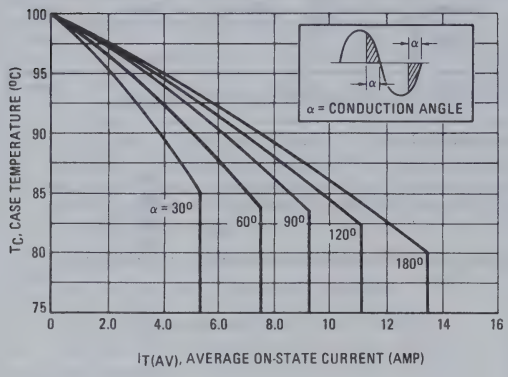


FIGURE 2 – RMS CURRENT DERATING

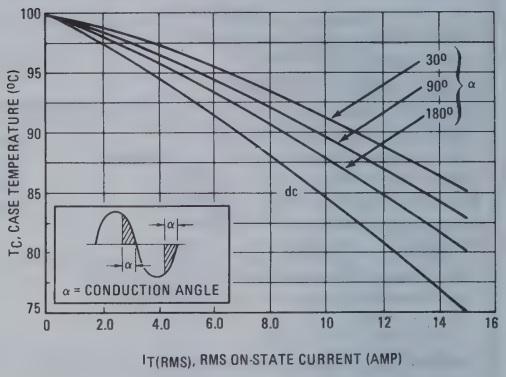


FIGURE 3 – ON-STATE POWER DISSIPATION

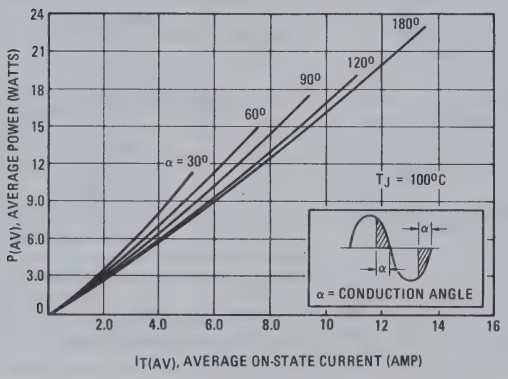


FIGURE 4 – ON-STATE POWER DISSIPATION

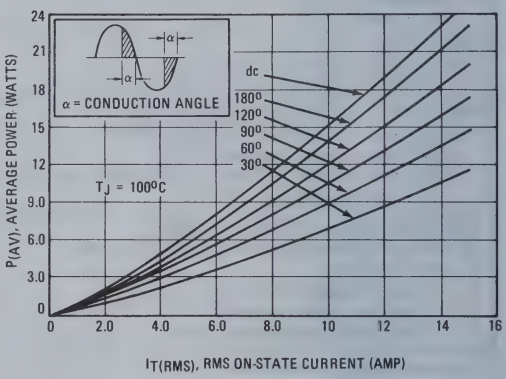


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

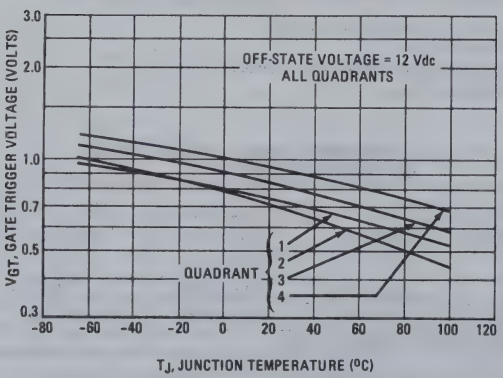


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

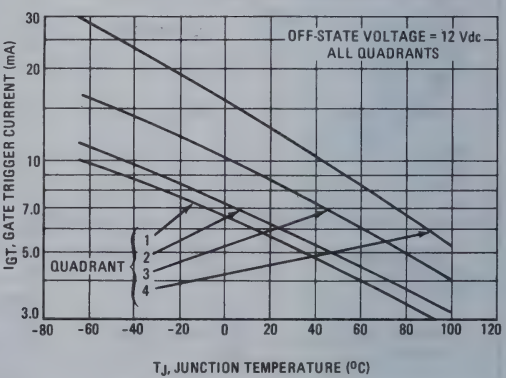


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

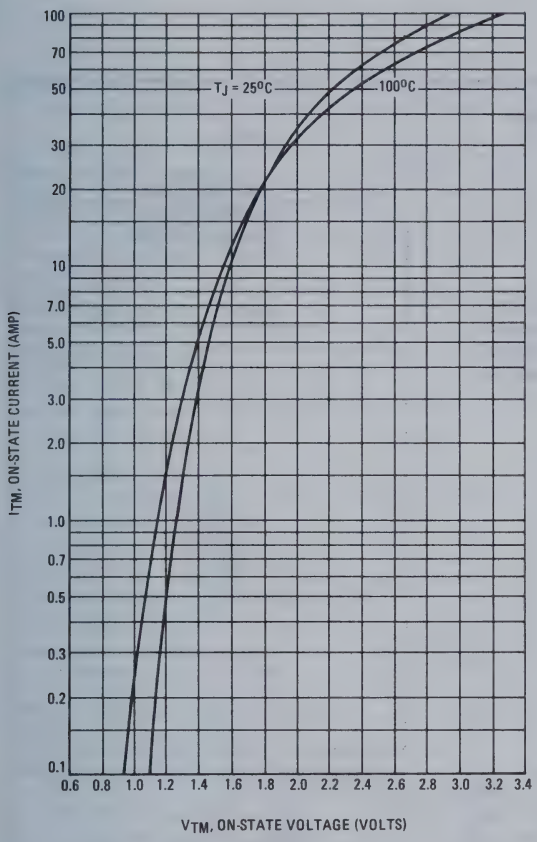


FIGURE 8 – TYPICAL HOLDING CURRENT

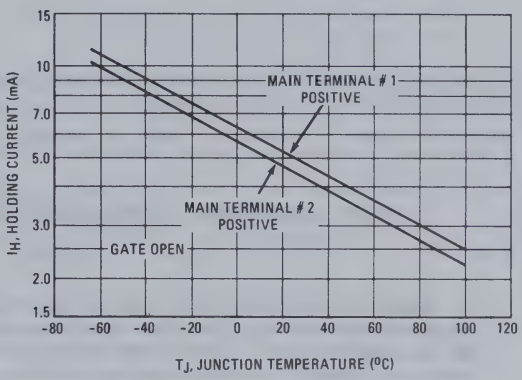


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

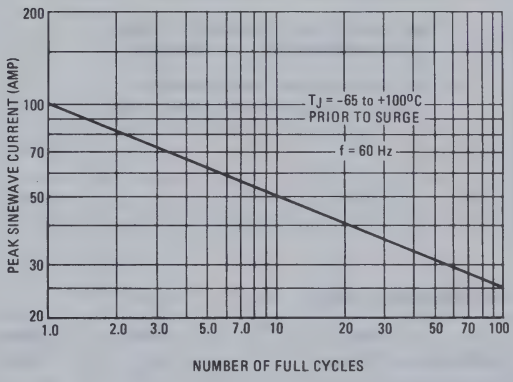
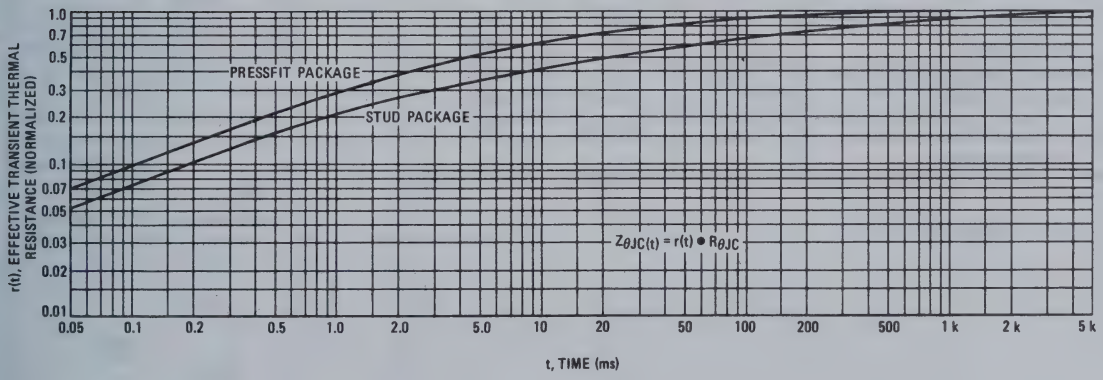


FIGURE 10 – TYPICAL THERMAL RESPONSE



2N5581, 2N5582 (SILICON)

For Specifications, See 2N2218,A, Volume I.

2N5583 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for applications in high frequency amplifiers and non-saturated switching circuits. Large signal capabilities, low-noise and high gain-bandwidth product characteristics of the 2N5583 provide excellent performance in a variety of small signal and linear amplifier applications. Ideal for C A T V circuits.

- High Current-Gain—Bandwidth Product —
  f_T = 1300 (Min) @ I_C = 100 mAdc
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 8.0 ps (Typ) @ I_C = 50 mAdc

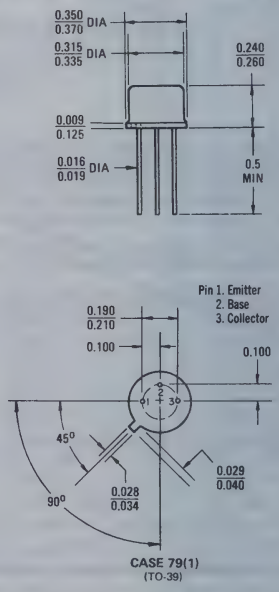
PNP SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
*Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 10 mAdc, I_B = 0)	–	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	–	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	–	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	4	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	–	I_{EBO}	–	–	0.5	μAdc
***ON CHARACTERISTICS**						
DC Current Gain (Note 1) (I_C = 40 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 300 mAdc, V_{CE} = 5.0 Vdc)	1	h_{FE}	 20 25 15	 40 40 22	 – 100 –	–
Collector-Emitter Saturation Voltage (Note 1) (I_C = 100 mAdc, I_B = 10 mAdc)	2,3	$V_{CE(sat)}$	–	0.6	0.8	Vdc
Base-Emitter On Voltage (Note 1) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	3	$V_{BE(on)}$	–	0.84	1.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
*Current-Gain—Bandwidth Product (I_C = 40 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	7	f_T	 1000 1300	 1300 1500	 – –	MHz
*Collector-Base Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	5	C_{cb}	–	2.5	5.0	pF
*Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	5	C_{eb}	–	18	35	pF
Collector-Base Time Constant (I_C = 50 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	8	$r_b'C_c$	–	8.0	–	ps
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 31.4 Vdc, I_C = 150 mAdc, R_C = 160 Ohms, R_E = 26.6 Ohms) (See Figure 10 for more detail)	9	t_d	–	1.0	–	ns
Rise Time		9	t_r	–	2.1	–	ns
Fall Time		9	t_f	–	1.8	–	ns

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – DC CURRENT GAIN

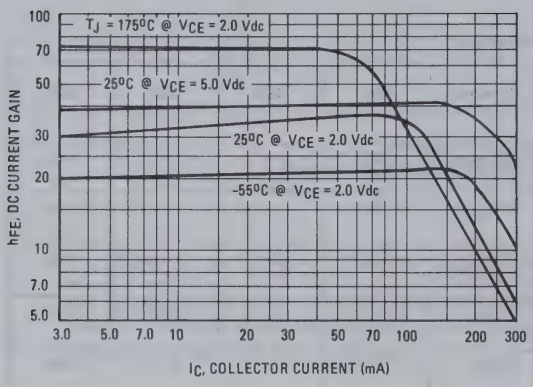


FIGURE 2 – COLLECTOR SATURATION REGION

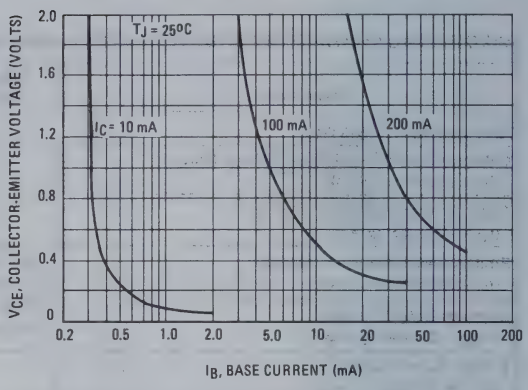


FIGURE 3 – "ON" VOLTAGES

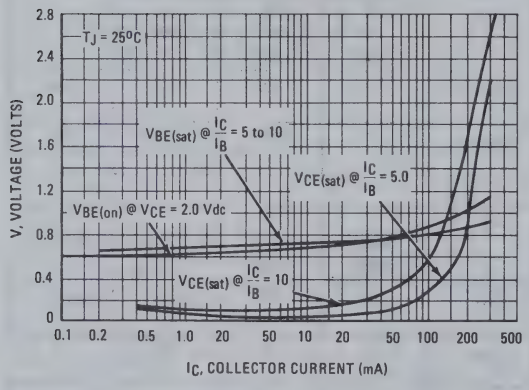


FIGURE 4 – COLLECTOR CURRENT versus BASE VOLTAGE

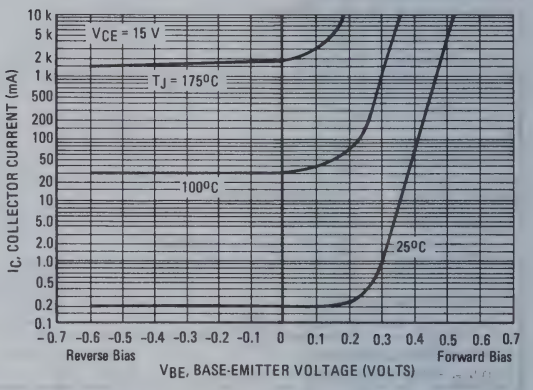


FIGURE 5 – CAPACITANCES

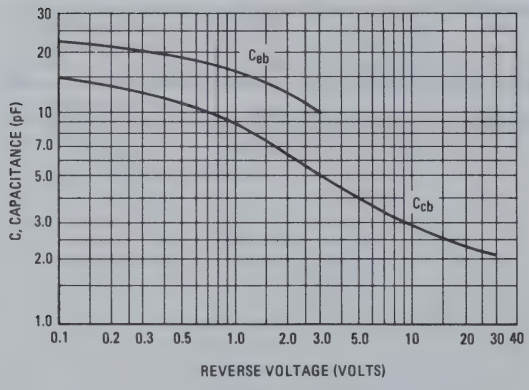


FIGURE 6 – TEMPERATURE COEFFICIENTS

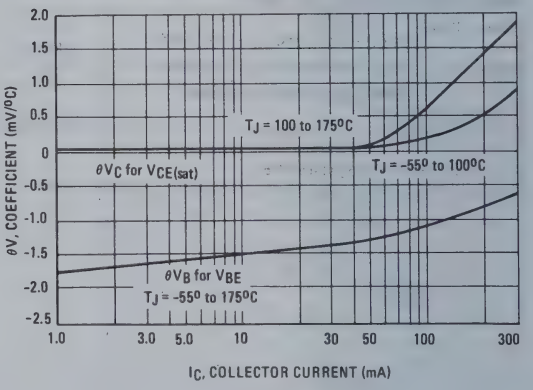


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

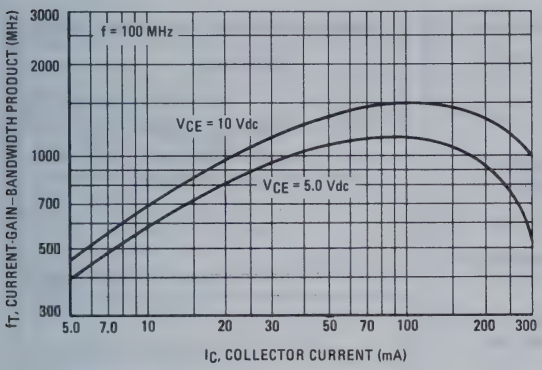


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

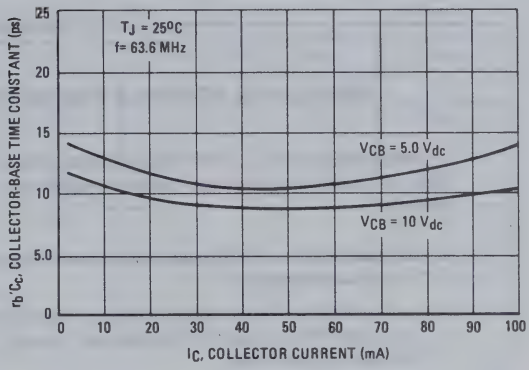


FIGURE 9 – SWITCHING TIMES

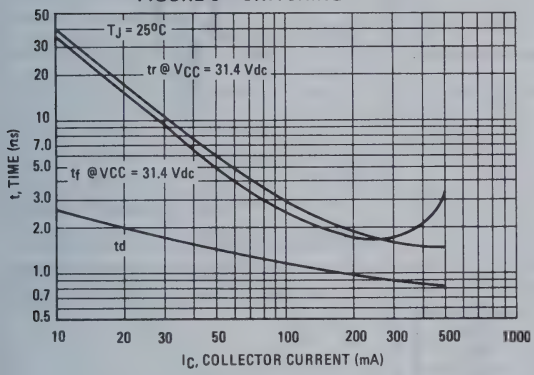
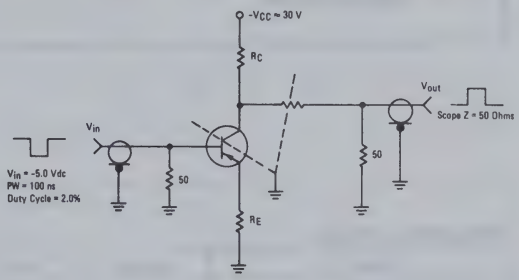


FIGURE 10 – SWITCHING TIMES TEST CIRCUIT



IC mA	RC Ohms	RE Ohms	VCC Volts
50	526	80	34.4
150	160	26.6	31.4
300	78	13.3	30.6
500	46.5	8.0	30.3

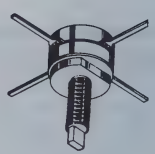
2N5589 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5589 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt, 175 MHz Characteristics –
  Output Power = 3.0 Watts
  Minimum Gain = 8.2 dB
  Efficiency = 50%

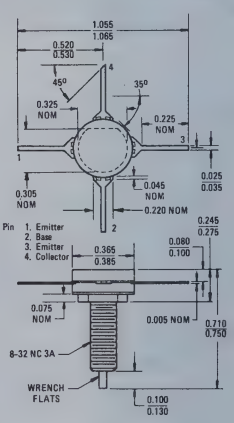
NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.6	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	15 86	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



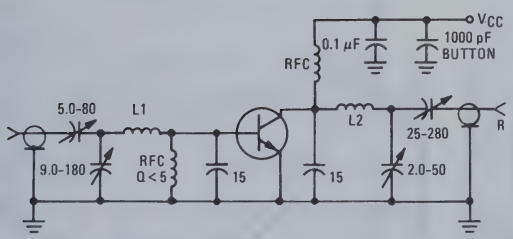
CASE 144B-02

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	15	30	pF
FUNCTIONAL TEST					
Power Input (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	0.35	0.45	Watt
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	8.2	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 175 MHz TEST CIRCUIT



All capacitance values in pF unless otherwise indicated
L1 – 1-3/8" length of #14 AWG Wire
L2 – 2 Turns #16 AWG Wire, 1/4" Dia. 1-1/2" Long

POWER OUTPUT versus FREQUENCY

FIGURE 2

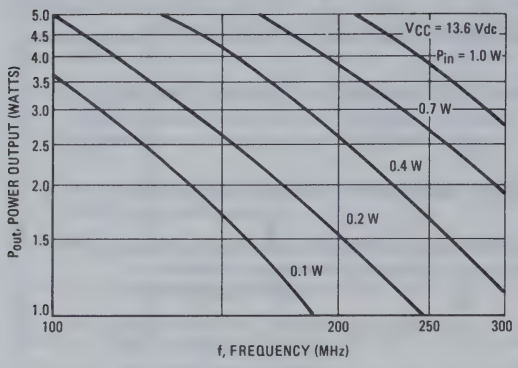


FIGURE 3

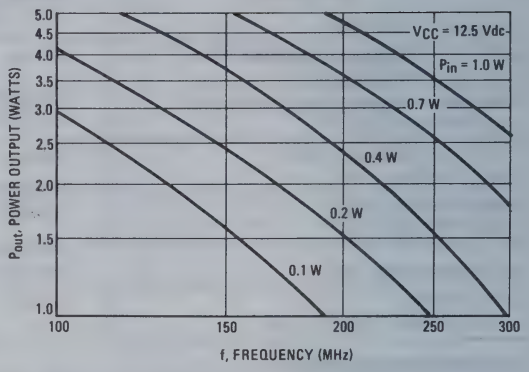


FIGURE 4 — POWER OUTPUT versus POWER INPUT

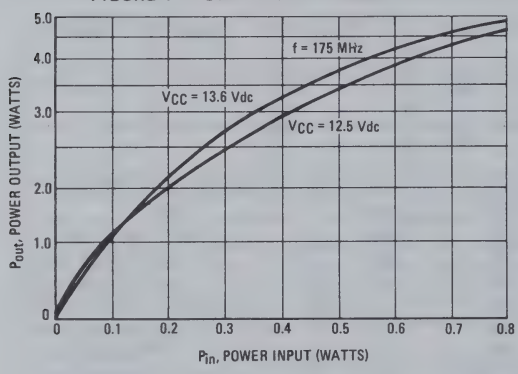
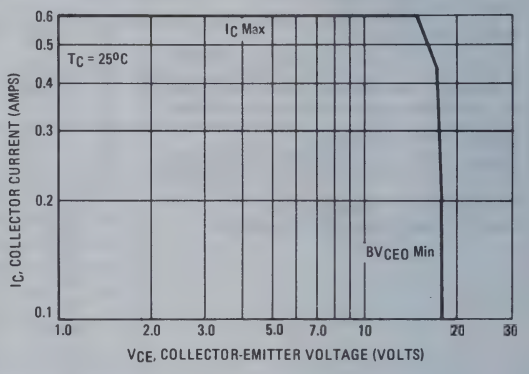


FIGURE 5 — DC SAFE OPERATING AREA



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6

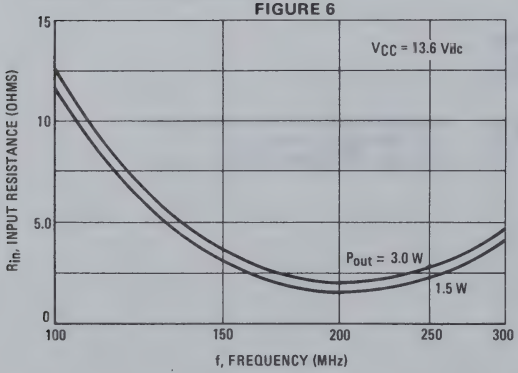
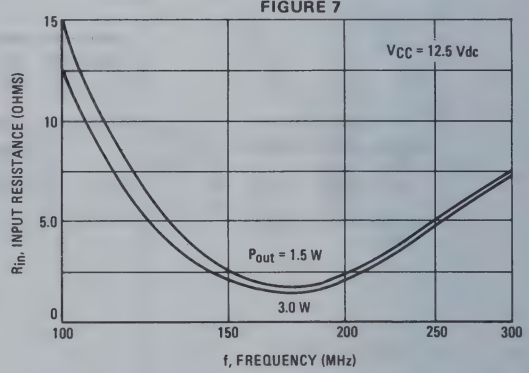


FIGURE 7



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8

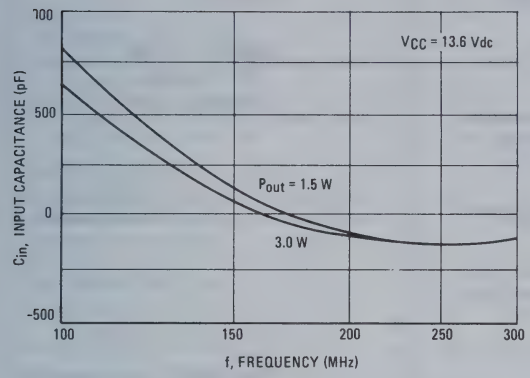
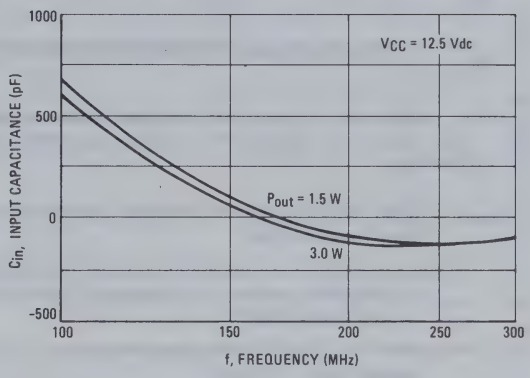


FIGURE 9



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10

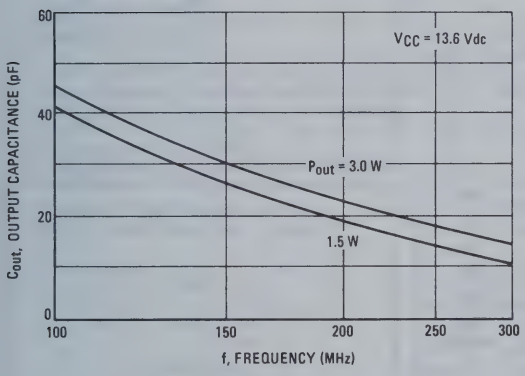
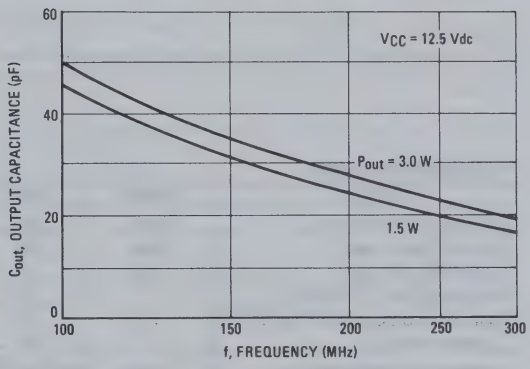


FIGURE 11



SERIES INPUT IMPEDANCE versus FREQUENCY

FIGURE 12

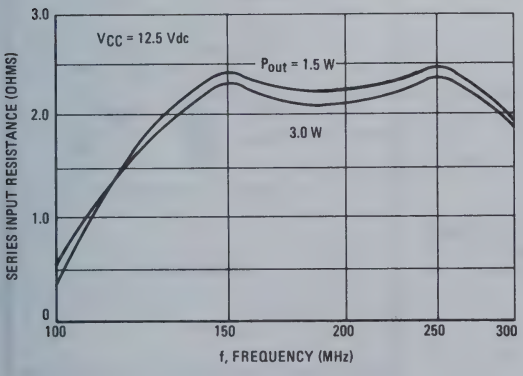
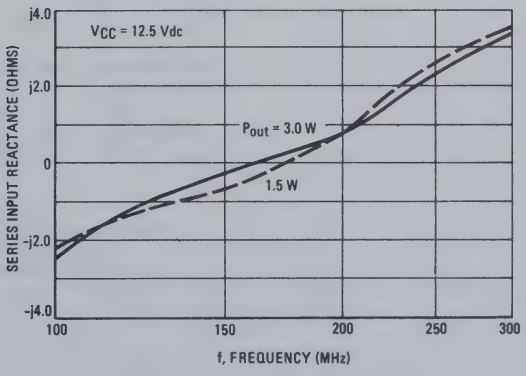


FIGURE 13



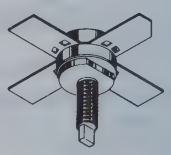
2N5590 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5590 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt, 175 MHz Characteristics —
  Output Power = 10 Watts
  Minimum Gain = 5.2 dB
  Efficiency = 50%

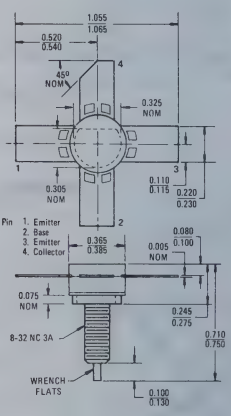
NPN SILICON RF POWER TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	30 171	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	^oC

*Indicates JEDEC Registered Data.



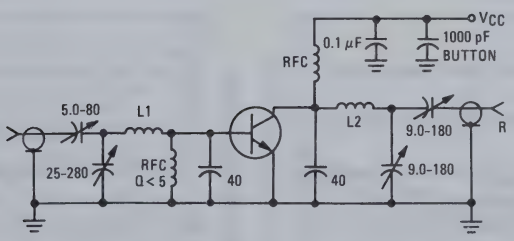
CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	18	–	–	Vdc
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, R_{BE} = 0)	$V_{CES(sus)}$	36	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 2.5 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
*Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	35	70	pF
FUNCTIONAL TEST					
*Power Input (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	–	3.0	Watts
*Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	5.2	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 175 MHz TEST CIRCUIT



All capacitance values in pF unless otherwise indicated
L1 – 1-3/8" length of #14 AWG Wire
L2 – 1 Turn #14 AWG Wire, 3/8" Dia. 1-1/2" Long

POWER OUTPUT versus FREQUENCY

FIGURE 2

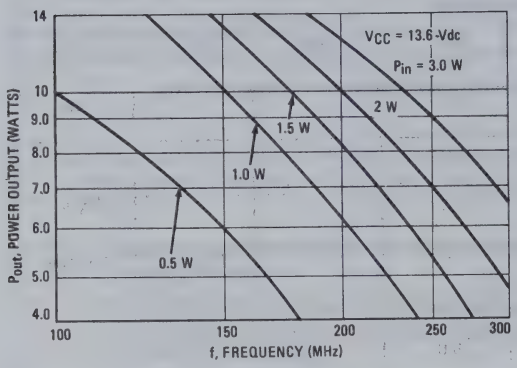


FIGURE 3

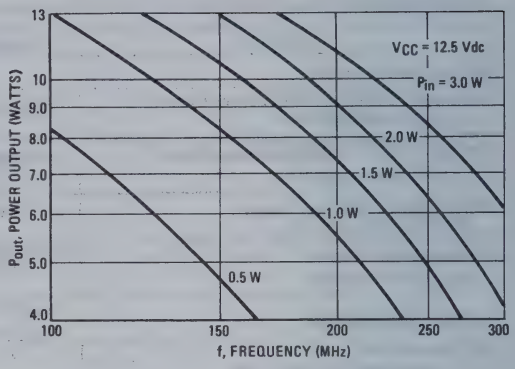


FIGURE 4 – POWER OUTPUT versus POWER INPUT

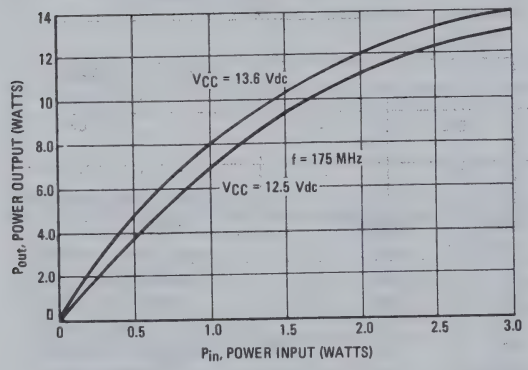
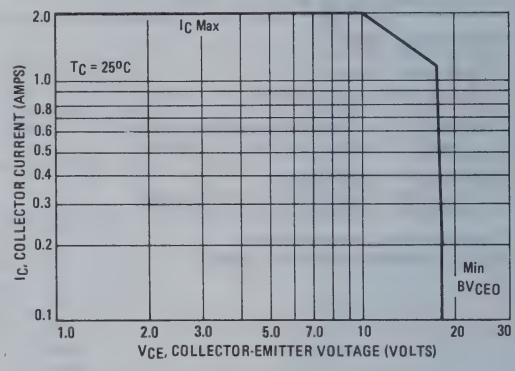


FIGURE 5 – DC SAFE OPERATING AREA



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6

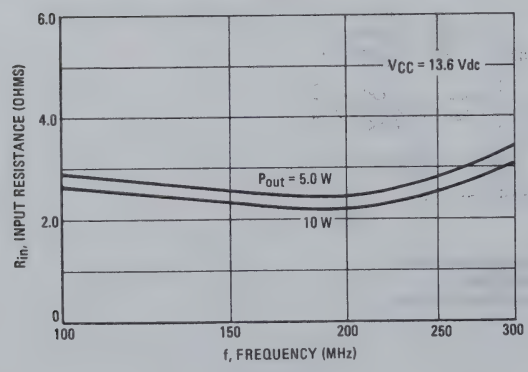
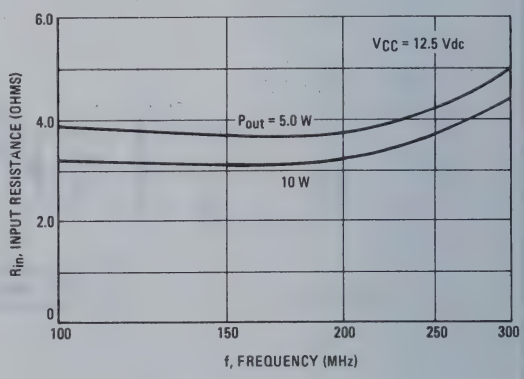


FIGURE 7



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8

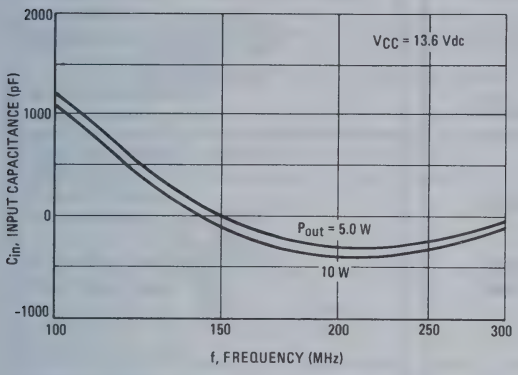
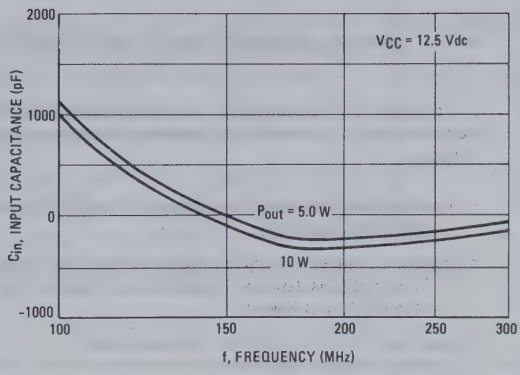


FIGURE 9



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10

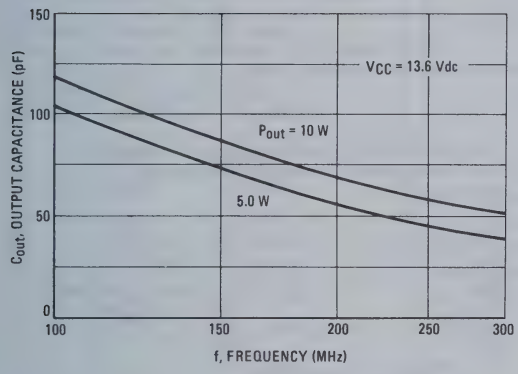
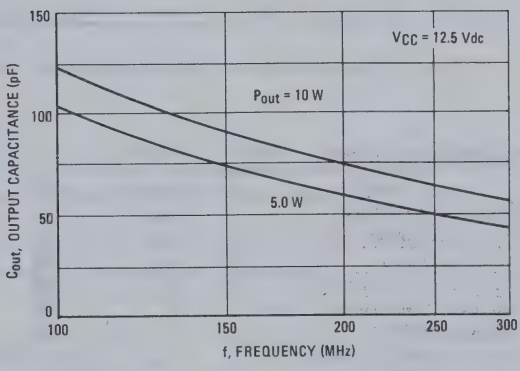


FIGURE 11



SERIES INPUT IMPEDANCE versus FREQUENCY

FIGURE 12

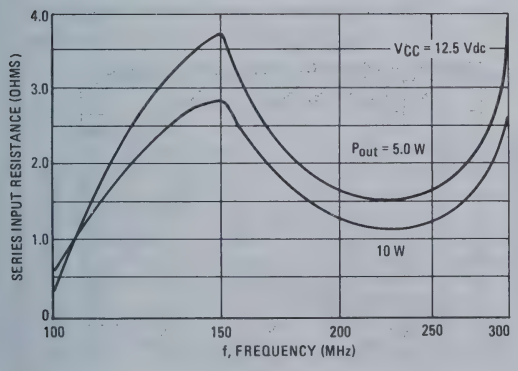
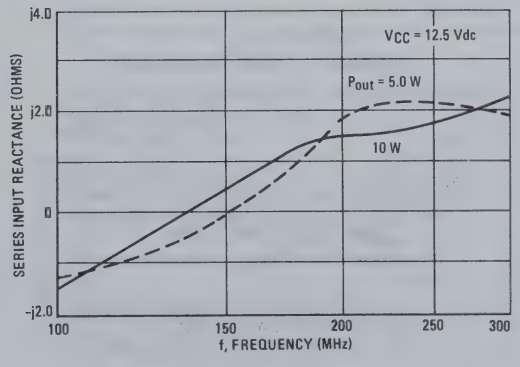


FIGURE 13



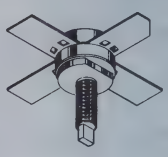
2N5591 (SILICON)

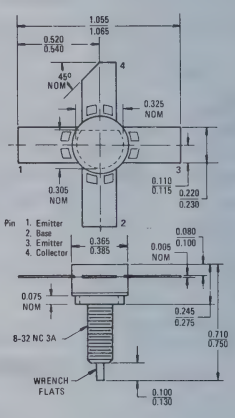
NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5591 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt. 175 MHz Characteristics —
  Output Power = 25 Watts
  Minimum Gain = 4.4 dB
  Efficiency = 50%

NPN SILICON RF POWER TRANSISTOR





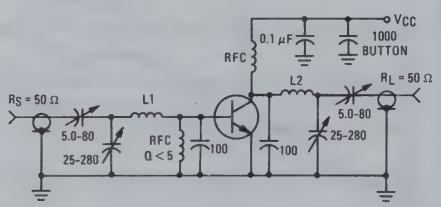
CASE 145A-01

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	70 400	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

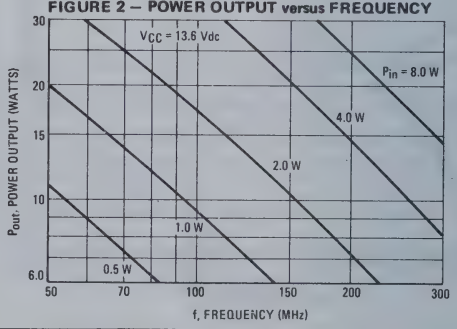
*Indicates JEDEC Registered Data.

FIGURE 1 — 175 MHz TEST CIRCUIT



ALL CAPACITORS IN pF UNLESS OTHERWISE INDICATED
L1 – #14 AWG STRAIGHT WIRE, 1–3/8" LONG
L2 – 1 TURN #14 AWG WIRE, 3/8" DIA. 1-1/2" LONG

FIGURE 2 — POWER OUTPUT versus FREQUENCY



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	18	–	–	Vdc
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	$V_{CES(sus)}$	36	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
***ON CHARACTERISTICS**					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
***DYNAMIC CHARACTERISTICS**					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	90	120	pF
***FUNCTIONAL TEST**					
Power Input (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	–	9.0	Watts
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	4.4	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 3 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

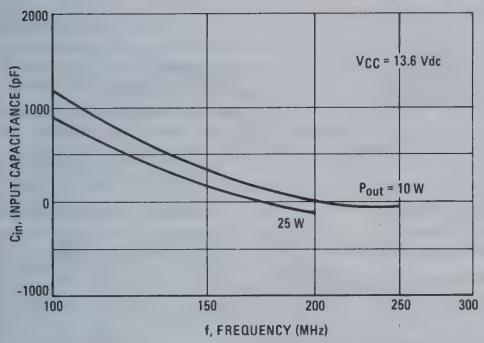


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

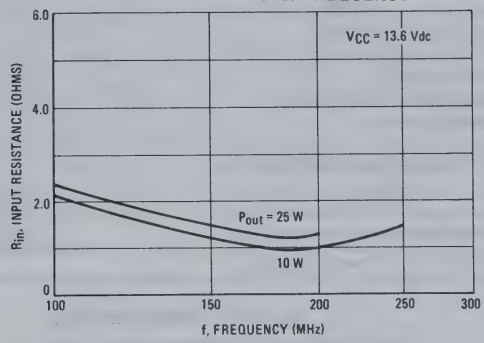


FIGURE 5 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

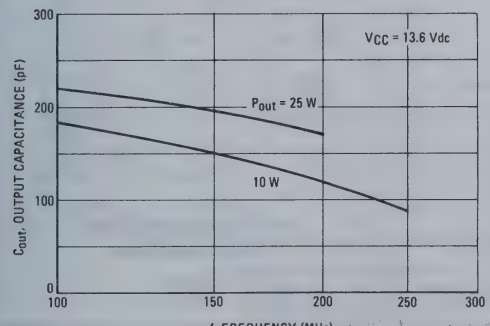
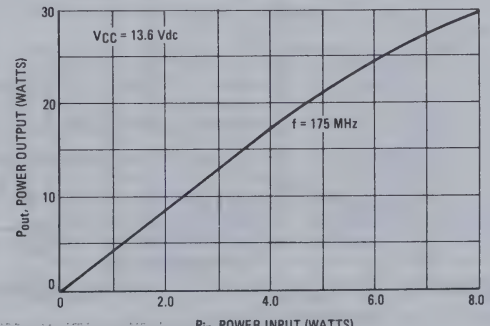


FIGURE 6 – POWER OUTPUT versus POWER INPUT



2N5629 (SILICON)
2N5630
2N5631

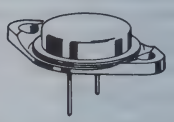
HIGH-VOLTAGE – HIGH POWER NPN TRANSISTORS

. . . designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc – 2N5629
  = 120 Vdc – 2N5630
  = 140 Vdc – 2N5631
- High DC Current Gain – @ I_C = 8.0 Adc
  h_{FE} = 25 (Min) – 2N5629
  = 20 (Min) – 2N5630
  = 15 (Min) – 2N5631
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 Adc
- Complement to PNP Transistor Series 2N6029, 2N6030, 2N6031

16 AMPERE
POWER TRANSISTORS
NPN SILICON

100-120-140 VOLTS
200 WATTS



*MAXIMUM RATINGS

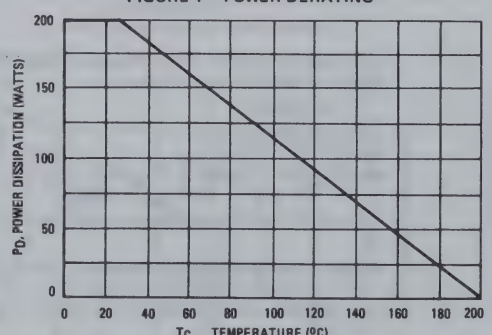
Rating	Symbol	2N5629	2N5630	2N5631	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	7.0			Vdc
Collector Current – Continuous Peak	I_C	16 20			Adc
Base Current – Continuous	I_B	5.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

*THERMAL CHARACTERISTICS

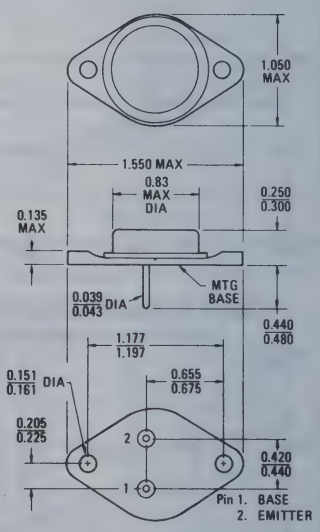
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING



Safe Area Curves are indicated by Figure 5. All Limits are applicable and must be observed.



All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

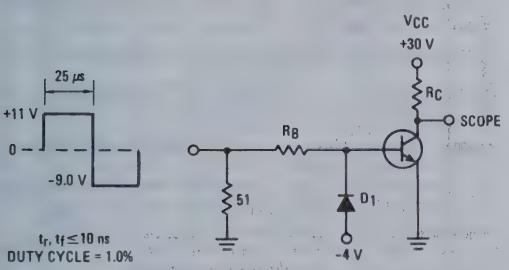
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5629		100	–	
	2N5630		120	–	
	2N5631		140	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N5629		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5630		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N5631		–	1.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Collector-Base Cutoff Current		I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)					
Emitter-Base Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)	2N5629		25	100	
	2N5630		20	80	
	2N5631		15	60	
(I_C = 16 Adc, V_{CE} = 2.0 Vdc)	All Types		4.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	All Types		–	1.0	
(I_C = 16 Adc, I_B = 4.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	–	1.8	Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)					
Base-Emitter On Voltage		$V_{BE(on)}$	–	1.5	Vdc
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2)		f_T	1.0	–	MHz
(I_C = 1.0 Adc, V_{CE} = 20 Vdc, f_{test} = 0.5 MHz)					
Output Capacitance		C_{ob}	–	500	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
Small-Signal Current Gain		h_{fe}	15	–	–
(I_C = 4.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FIGURE 3 – TURN-ON TIME

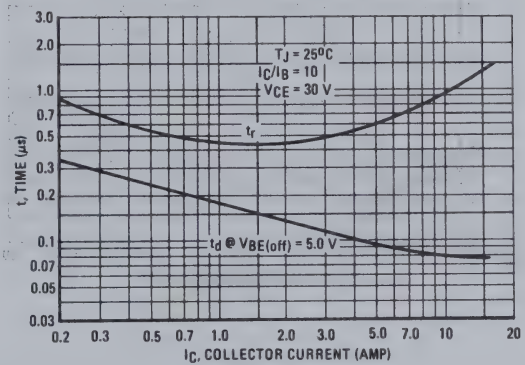


FIGURE 4 – THERMAL RESPONSE

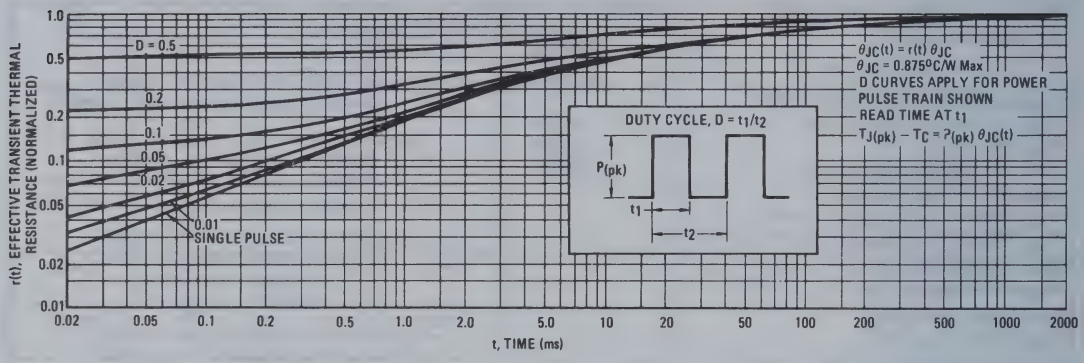
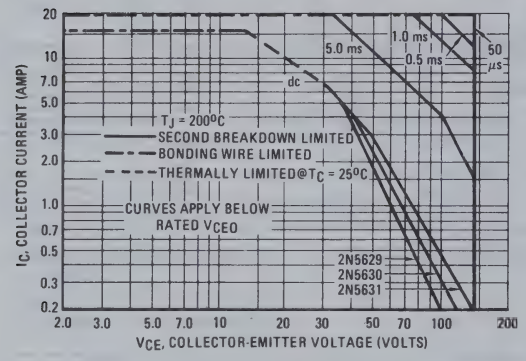


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

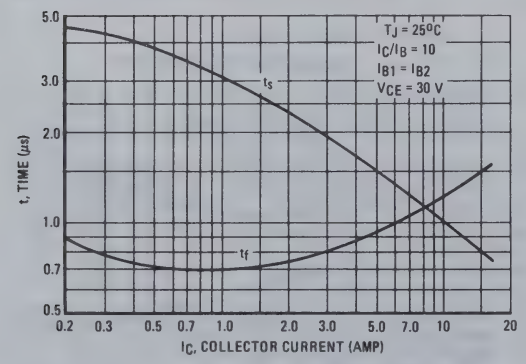


FIGURE 7 – CAPACITANCE

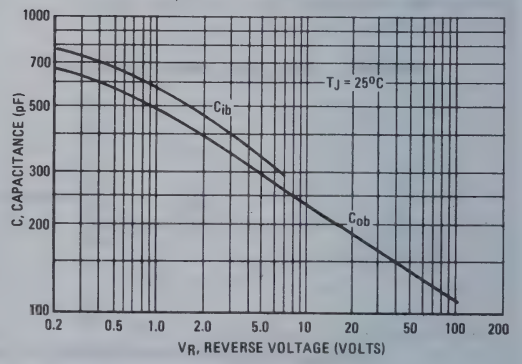


FIGURE 8 – DC CURRENT GAIN

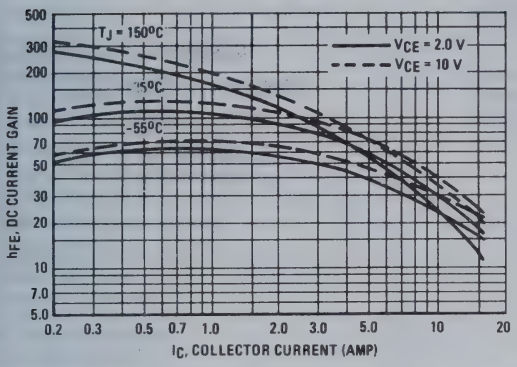


FIGURE 9 – COLLECTOR SATURATION REGION

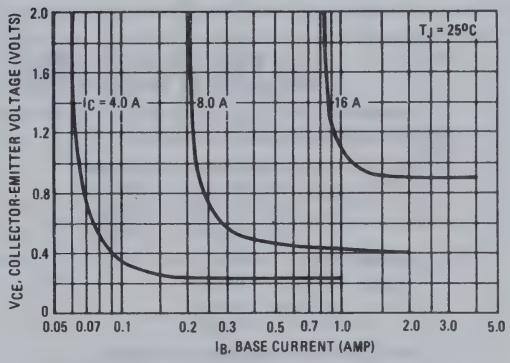


FIGURE 10 – ON VOLTAGES

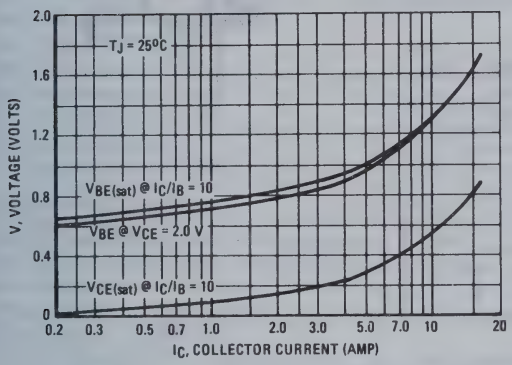


FIGURE 11 – TEMPERATURE COEFFICIENTS

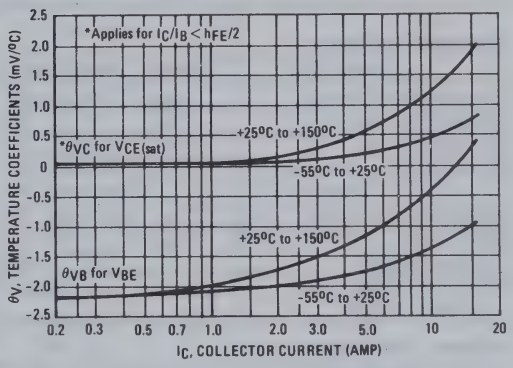


FIGURE 12 – COLLECTOR CUTOFF REGION

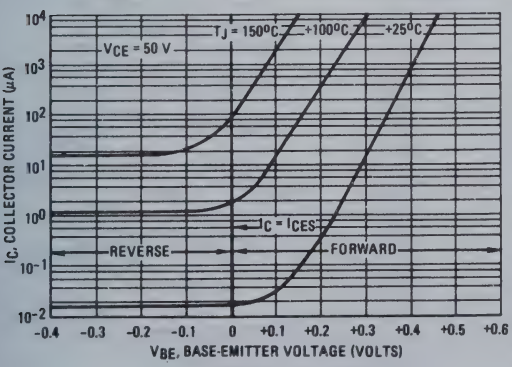
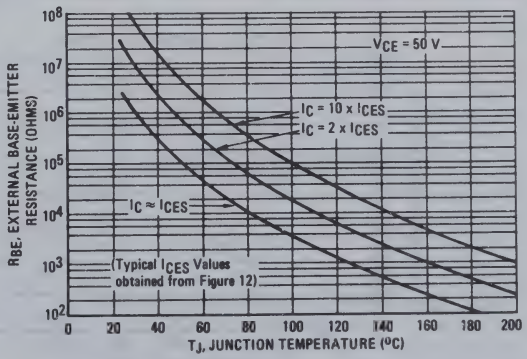


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



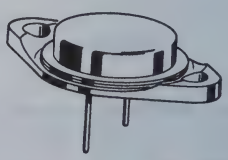
2N5632 (SILICON)
2N5633
2N5634

HIGH VOLTAGE-HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in high power audio amplifier applications and high-voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) – 2N5632
  = 120 Vdc (Min) – 2N5633
  = 140 Vdc (Min) – 2N5634
- High DC Current Gain @ I_C = 5.0 Adc –
  h_{FE} = 25 (Min) – 2N5632
  = 20 (Min) – 2N5633
  = 15 (Min) – 2N5634
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 7.5 Adc
- Complement to PNP Transistor Series
  2N6229, 2N6230, 2N6231

10 AMPERE
POWER TRANSISTOR
NPN SILICON
100-120-140 VOLTS
150 WATTS



*MAXIMUM RATINGS

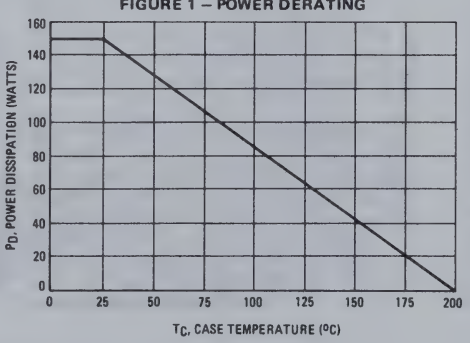
Rating	Symbol	2N5632	2N5633	2N5634	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current – Continuous	I_C	← 10 →			Adc
– Peak		← 15 →			
Base Current – Continuous	I_B	← 5.0 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 150 →			Watts
Derate above 25°C		← 0.857 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

*THERMAL CHARACTERISTICS

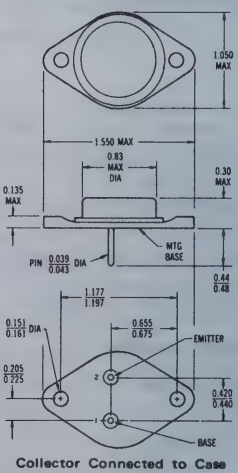
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING



Safe area limits are indicated by Figure 5.
Both limits are applicable and must be observed.



Collector Connected to Case

CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

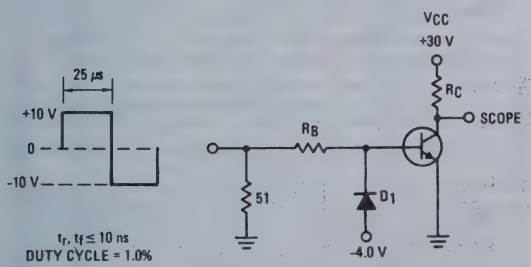
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	2N5632	$V_{CEO(sus)}$	100	–	Vdc
	2N5633		120	–	
	2N5634		140	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N5632		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5633		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N5634		–	1.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Collector Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	1.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain[1]		h_{FE}			–
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5632		25	100	
	2N5633		20	80	
	2N5634		15	60	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	All Types		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 7.5 Adc, I_B = 0.75 Adc)			–	1.0	
(I_C = 10 Adc, I_B = 2.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage (I_C = 7.5 Adc, I_B = 0.75 Adc)		$V_{BE(sat)}$	–	2.0	Vdc
Base-Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 20 Vdc, f_{test} = 0.5 MHz)		f_T	1.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	300	pF
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 2.0 Adc, f = 1.0 kHz)		h_{fe}	15	–	–

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈100 mA
MSD6100 USED BELOW I_B ≈100 mA

FIGURE 3 – TURN-ON TIME

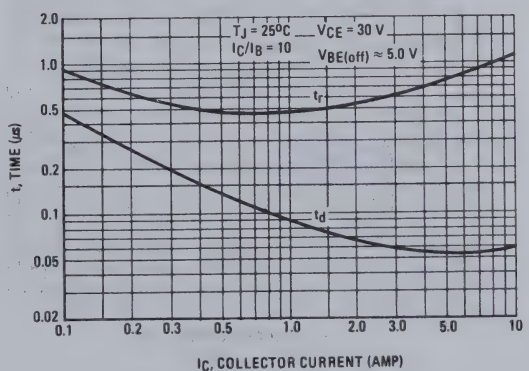


FIGURE 4 – THERMAL RESPONSE

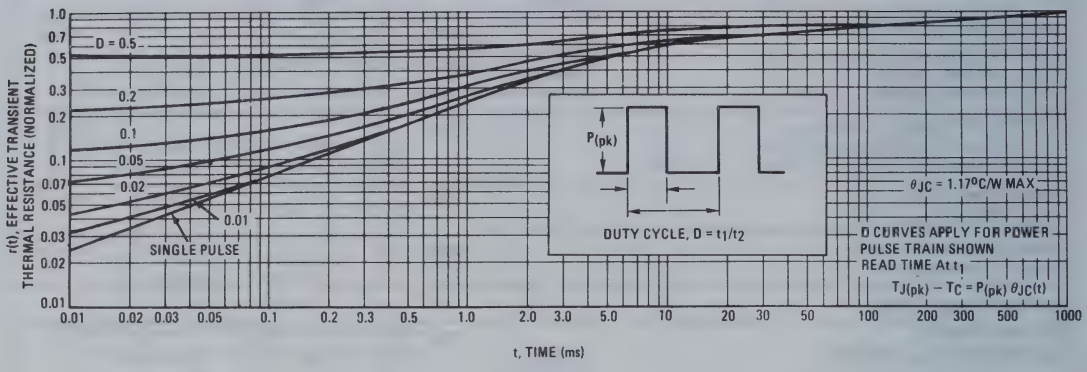
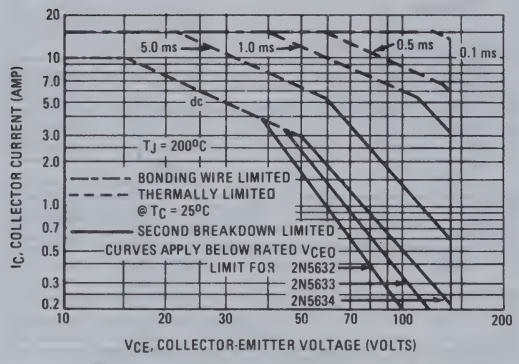


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

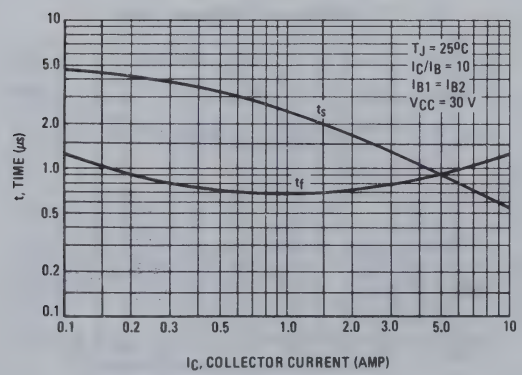


FIGURE 7 – CAPACITANCE

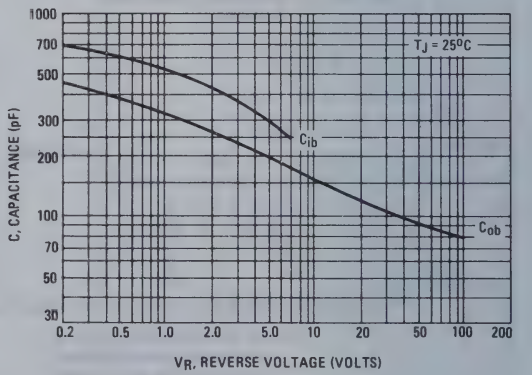


FIGURE 8 – DC CURRENT GAIN

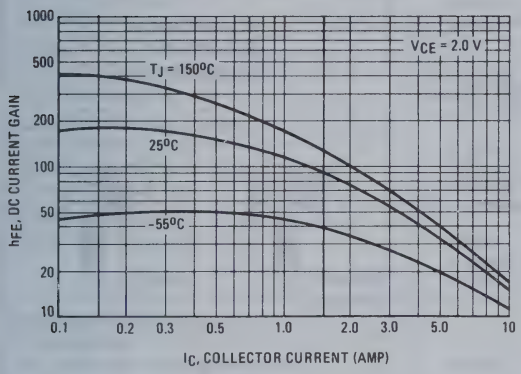


FIGURE 9 – COLLECTOR SATURATION REGION

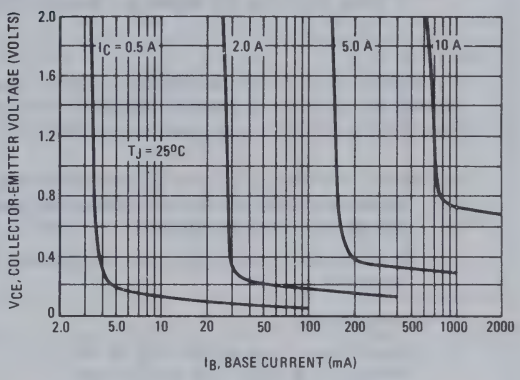


FIGURE 10 – "ON" VOLTAGES

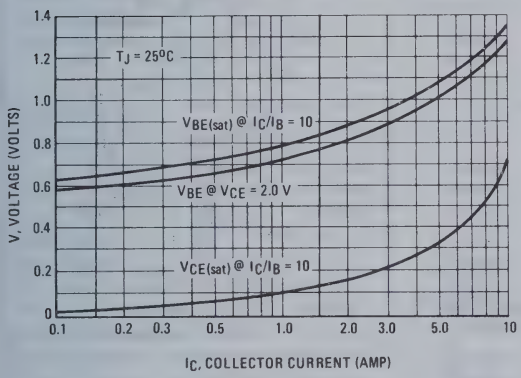


FIGURE 11 – TEMPERATURE COEFFICIENTS

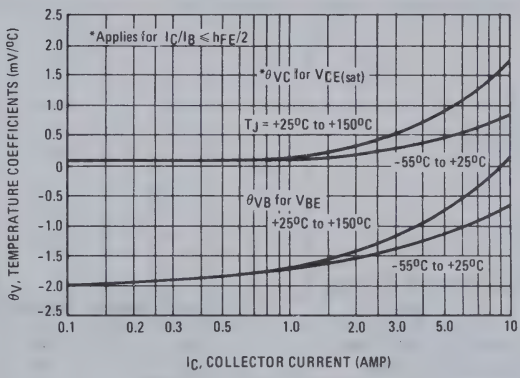


FIGURE 12 – COLLECTOR CUTOFF REGION

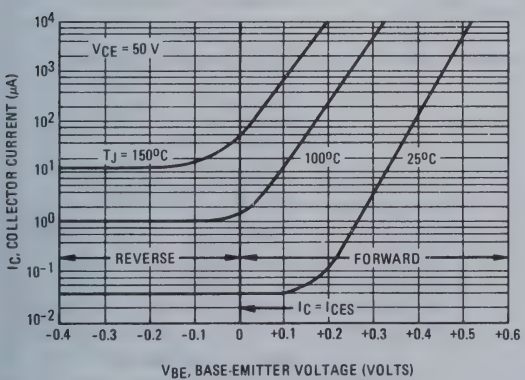
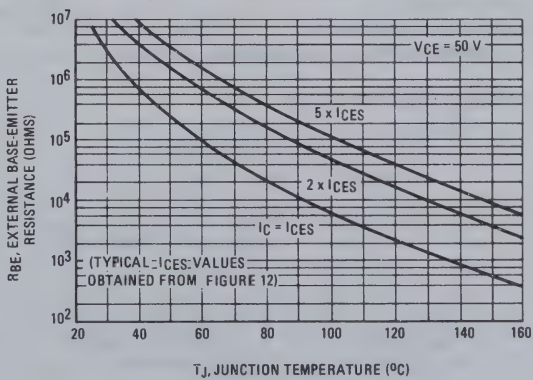


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



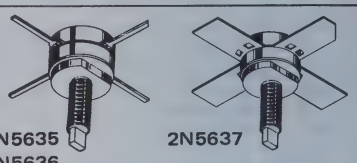
2N5635 (SILICON)
2N5636
2N5637

NPN SILICON RF POWER TRANSISTORS

. . . designed for VHF/UHF amplifier applications. These devices are suitable for use in 28 volt systems to 470 MHz. These transistors are ideal for 225-400 MHz communications equipment.

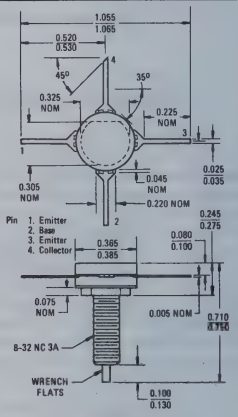
- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.
- Low inductance strip line packaging for easier and better broadband designs.
- Ceramic Package
- Choice of Power Levels at 400 MHz, 28 Vdc –
  2N5635 – 2.5 Watts – 6.2 dB (Min) Gain
  2N5636 – 7.5 Watts – 5.7 dB (Min) Gain
  2N5637 – 20 Watts – 4.6 dB (Min) Gain

NPN SILICON RF POWER TRANSISTORS

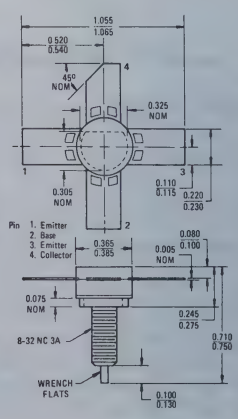


2N5635
2N5636

2N5637



CASE 1448-02
2N5635, 2N5636



2N5637 CASE 145A-01

***MAXIMUM RATINGS**

Rating	Symbol	2N5635	2N5636	2N5637	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 60 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current	I_C	1.0	1.5	3.0	Adc
Total Device Dissipation @ $T_A = 25^oC$	P_D	7.5	15	30	Watts
Derate above 25^oC		43	86	171	mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^{o}C

*Indicates JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CEO}				Vdc
(I_C = 100 mAdc, I_B = 0)	2N5635		35	–	–	
(I_C = 200 mAdc, I_B = 0)	2N5636,2N5637		35	–	–	
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CES}				Vdc
(I_C = 100 mAdc, V_{BE} = 0)	2N5635		60	–	–	
(I_C = 200 mAdc, V_{BE} = 0)	2N5636,2N5637		60	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N5635		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	2N5636		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N5637		4.0	–	–	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N5635		–	–	0.1	
	2N5636		–	–	1.0	
	2N5637		–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N5635		5.0	–	–	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	2N5636		5.0	–	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5637		5.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5635		–	5.0	10	
	2N5636		–	10	20	
	2N5637		–	20	30	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		6.2	9.2	–	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		5.7	7.0	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		4.6	5.8	–	
Power Output		P_{out}				Watts
(P_{in} = 0.6 Watt, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		2.5	3.2	–	
(P_{in} = 2.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		7.5	8.4	–	
(P_{in} = 7.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		20	22	–	
Collector Efficiency		η				%
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		50	–	–	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		50	–	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		60	–	–	

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 400 MHz TEST CIRCUIT (2N5635,2N5636)

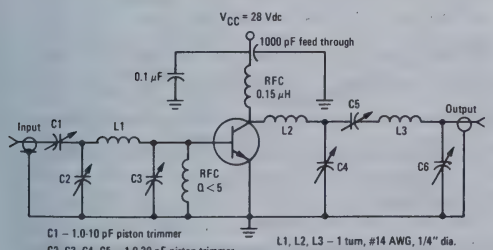
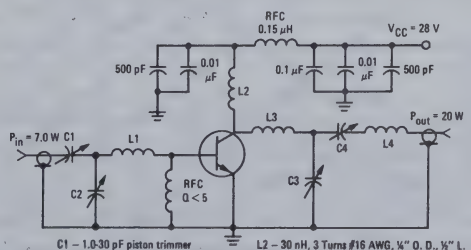


FIGURE 2 – 400 MHz TEST CIRCUIT (2N5637)



TYPICAL PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 3

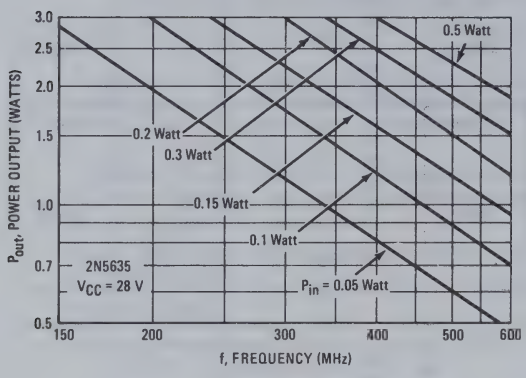


FIGURE 4

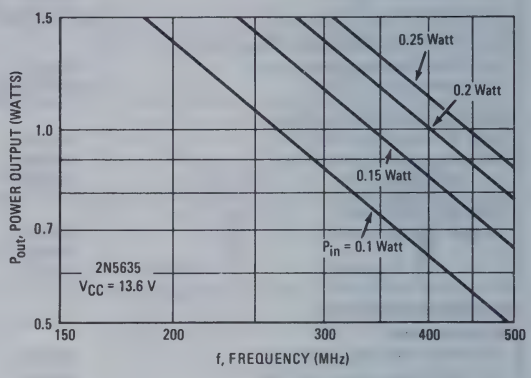


FIGURE 5

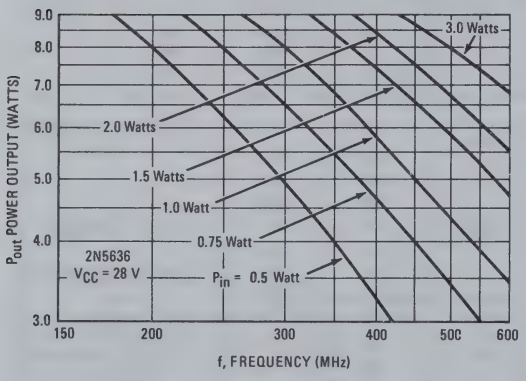


FIGURE 6

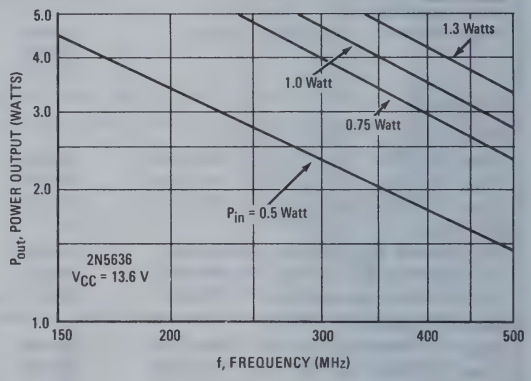


FIGURE 7

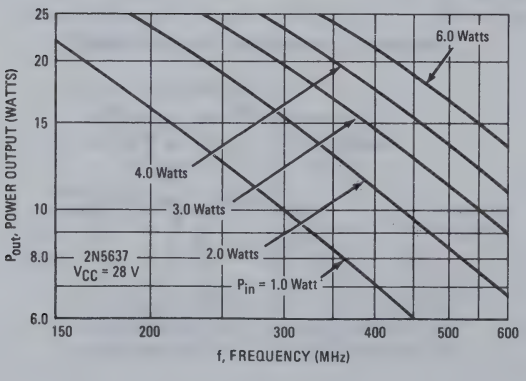
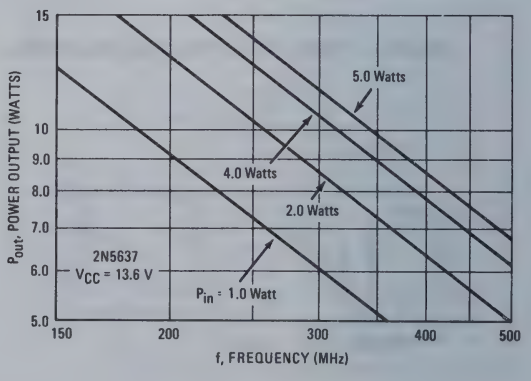


FIGURE 8



TYPICAL PERFORMANCE DATA

POWER OUTPUT versus POWER INPUT

FIGURE 9

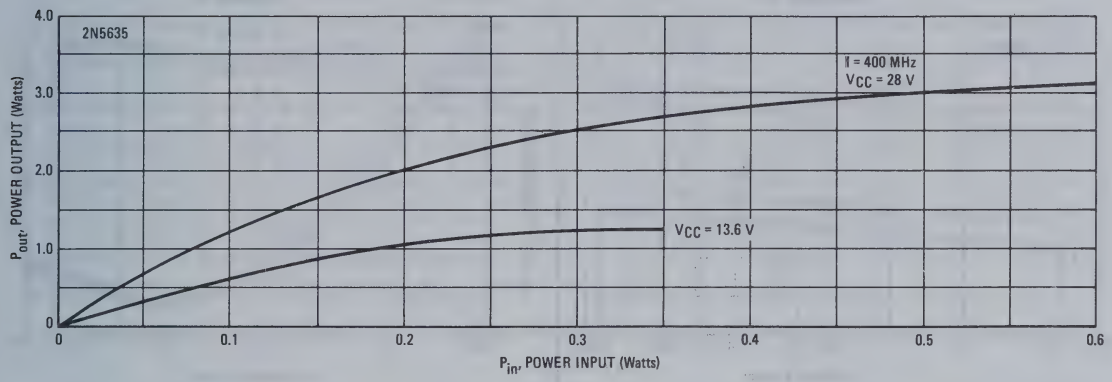


FIGURE 10

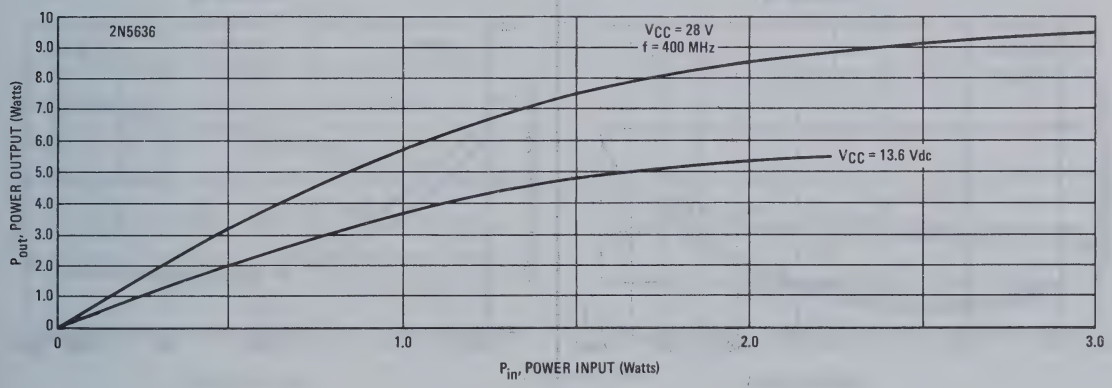
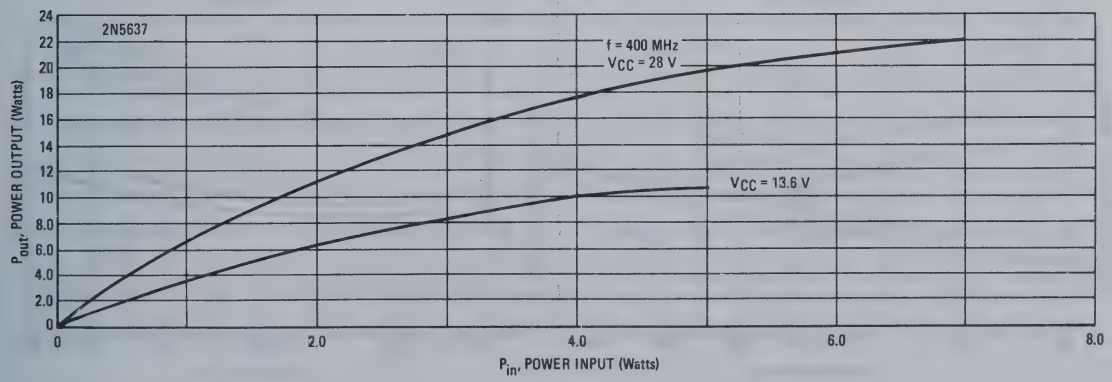


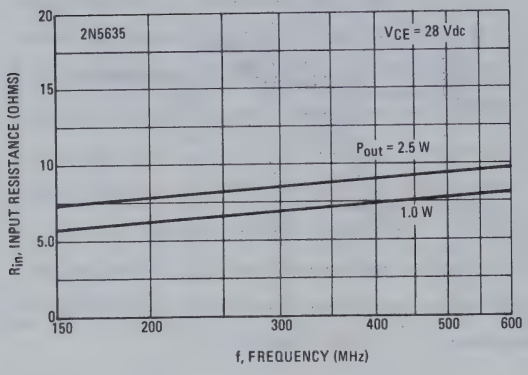
FIGURE 11



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 12



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 13

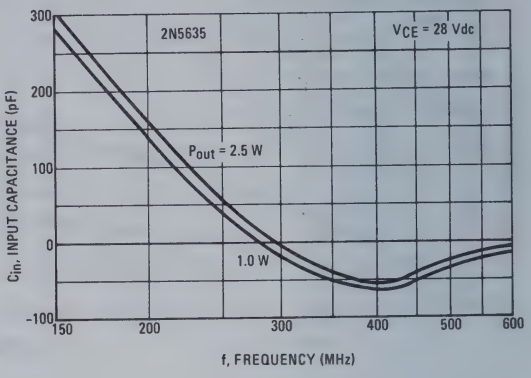


FIGURE 14

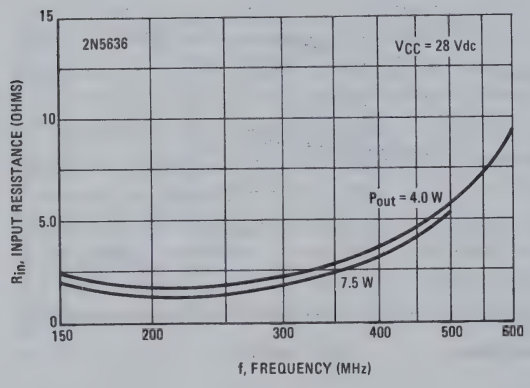


FIGURE 15

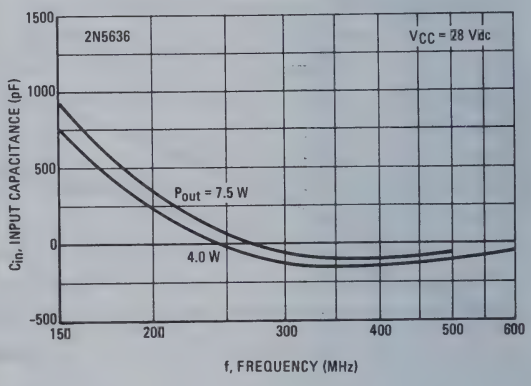


FIGURE 16

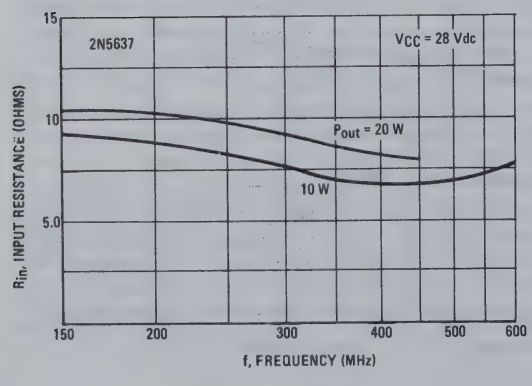
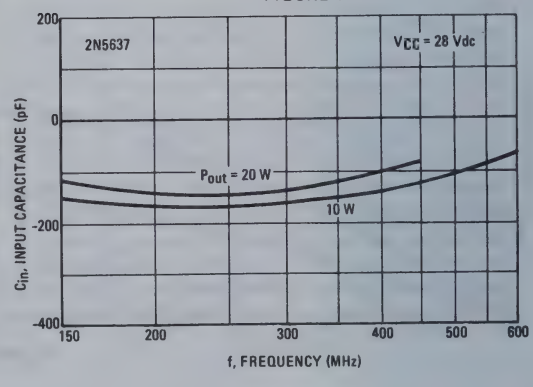


FIGURE 17



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 18

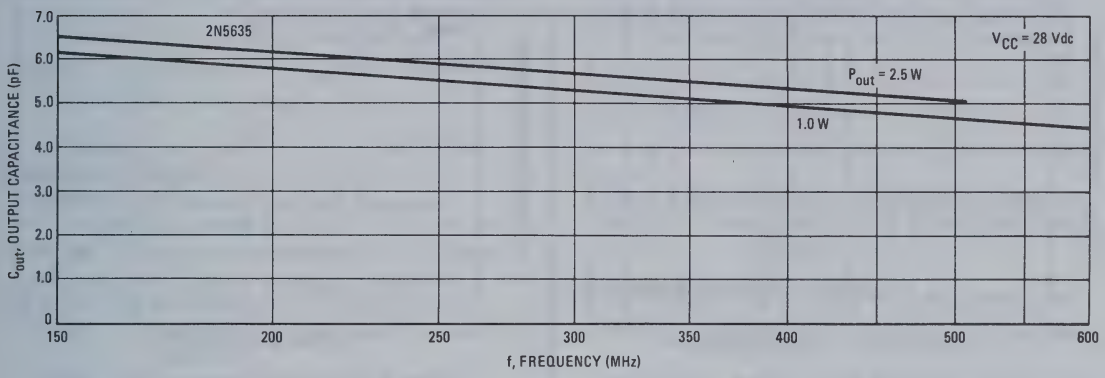


FIGURE 19

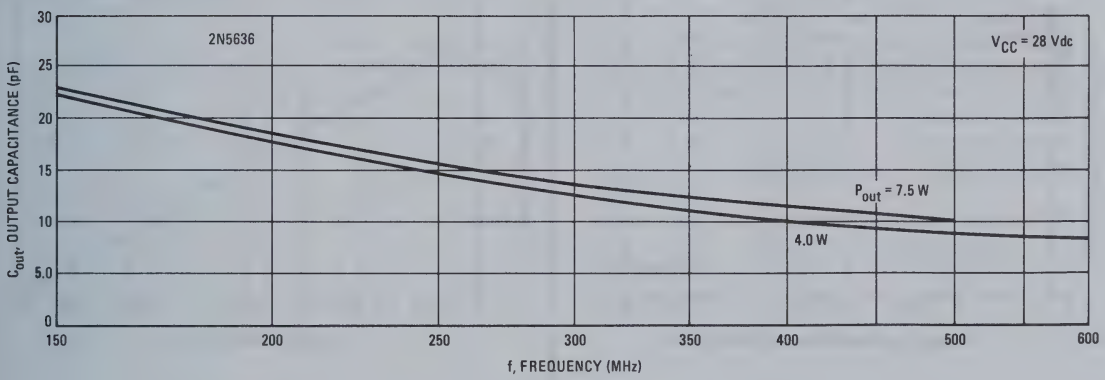
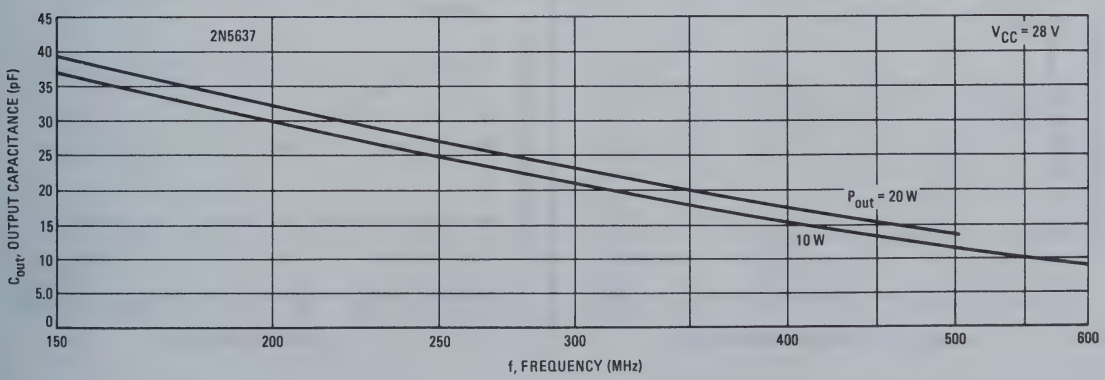


FIGURE 20



DC SAFE OPERATING AREA

FIGURE 21

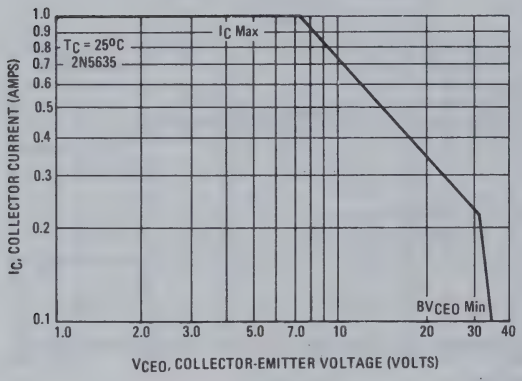


FIGURE 23

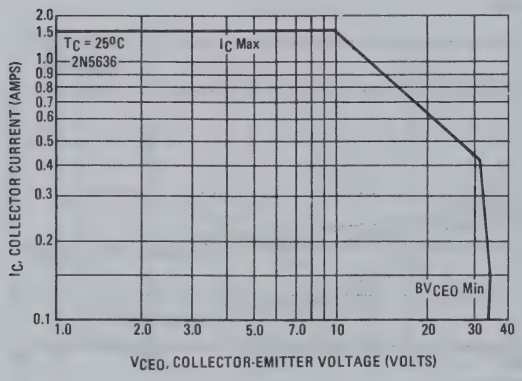
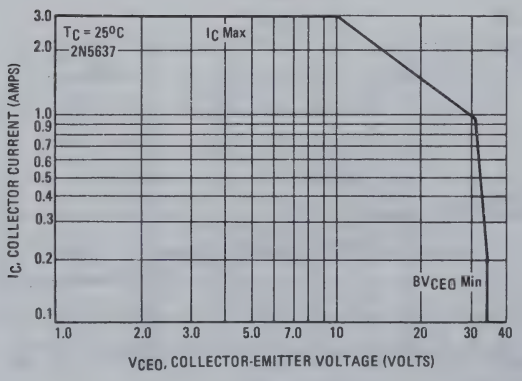


FIGURE 25



POWER DISSIPATION DERATING CURVE

FIGURE 22

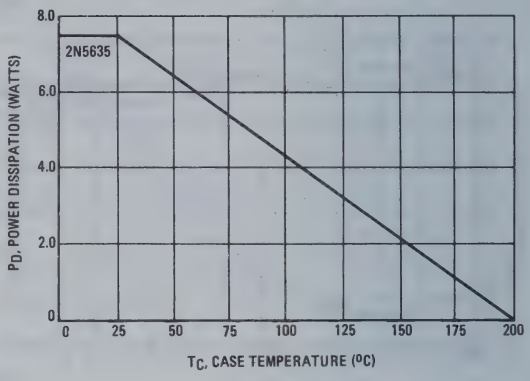


FIGURE 24

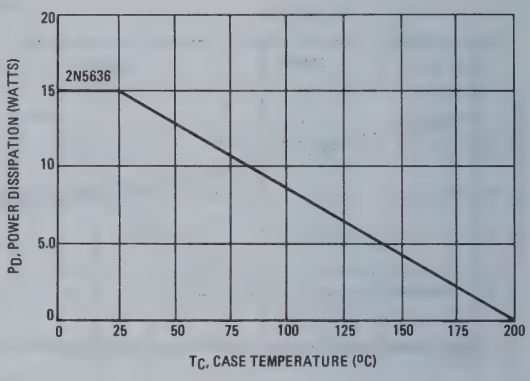
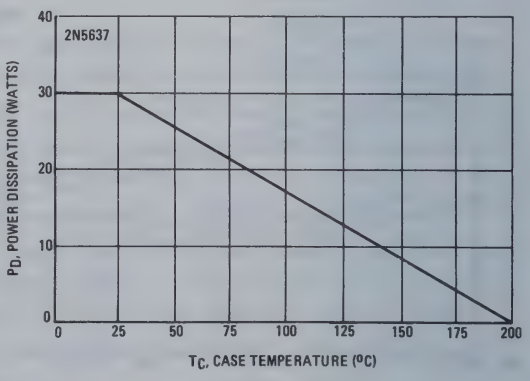


FIGURE 26



APPLICATION INFORMATION

In addition to a fine selection of quality RF Semiconductors, Motorola provides applications information in the form of Application Notes. Any of the notes listed on this page may be obtained by writing to the Technical Information Center, Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Arizona.

Small Signal RF Design

AN-139A- Understanding Transistor Response Parameters
AN-166 – Using Linvill Techniques for RF Amplifiers
AN-215A – RF Small Signal Design Using 2-Port Parameters
AN-238 – Transistor Mixer Design Using Admittance Parameters
AN-247 – An Integrated Circuit RF-IF Amplifier
AN-406A- UHF Broadband Amplifier Design
AN-419 – UHF Amplifier Design Using Data Sheet Curves
AN-421 – Semiconductor Noise Figure Considerations
AN-423 – Field-Effect Transistor RF Amplifier Design Techniques

RF Power Transistor Circuit Design

AN-267 – Matching Network Designs with Computer Solutions
AN-282A – Systemizing RF Power Amplifier Design

2N5638 (SILICON)
2N5639
2N5640

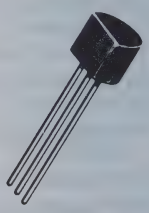
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 30 Ohms (2N5638)
  60 Ohms (2N5639)
  100 Ohms (2N5640)
- Low Reverse Transfer Capacitance —
  C_{rss} = 4.0 pF (Max) @ f = 1.0 MHz
- Fast Switching Characteristics —
  t_r = 5.0 ns (Max) (2N5638)

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

TYPE A

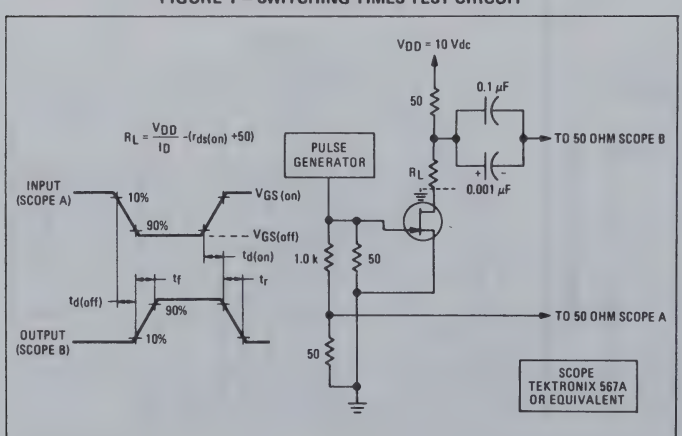


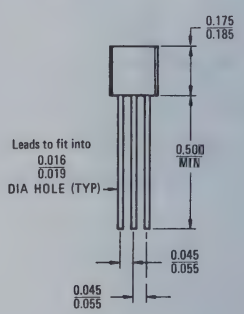
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
*Drain-Gate Voltage	V_{DG}	30	Vdc
*Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
*Forward Gate Current	I_{GF}	10	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
*Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT





Case 29 (5)
(TO-92)

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	Vdc
Gate Reverse Current		I_{GSS}			
(V_{GS} = –15 Vdc, V_{DS} = 0)			–	1.0	nAdc
(V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = –12 Vdc)	2N5638		–	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = –8.0 Vdc)	2N5639		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = –6.0 Vdc)	2N5640		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = –12 Vdc, T_A = 100°C)	2N5638		–	1.0	μAdc
(V_{DS} = 15 Vdc, V_{GS} = –8.0 Vdc, T_A = 100°C)	2N5639		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = –6.0 Vdc, T_A = 100°C)	2N5640		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N5638		50	–	
	2N5639		25	–	
	2N5640		5.0	–	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 12 mAdc, V_{GS} = 0)	2N5638		–	0.5	
(I_D = 6.0 mAdc, V_{GS} = 0)	2N5639		–	0.5	
(I_D = 3.0 mAdc, V_{GS} = 0)	2N5640		–	0.5	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	2N5638		–	30	
	2N5639		–	60	
	2N5640		–	100	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N5638		–	30	
	2N5639		–	60	
	2N5640		–	100	
Input Capacitance (V_{DS} = 0, V_{GS} = –12 Vdc, f = 1.0 MHz)		C_{iss}	–	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = –12 Vdc, f = 1.0 MHz)		C_{rss}	–	4.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Delay Time	V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = –10 Vdc, R_G' = 50 ohms	$I_{D(on)}$ = 12 mAdc 2N5638	$t_{d(on)}$	–	4.0	ns
		6.0 mAdc 2N5639		–	6.0	
		3.0 mAdc 2N5640		–	8.0	
Rise Time		$I_{D(on)}$ = 12 mAdc 2N5638	t_r	–	5.0	ns
		6.0 mAdc 2N5639		–	8.0	
		3.0 mAdc 2N5640		–	10	
Turn-Off Delay Time		$I_{D(on)}$ = 12 mAdc 2N5638	$t_{d(off)}$	–	5.0	ns
		6.0 mAdc 2N5639		–	10	
		3.0 mAdc 2N5640		–	15	
Fall Time		$I_{D(on)}$ = 12 mAdc 2N5638	t_f	–	10	ns
		6.0 mAdc 2N5639		–	20	
		3.0 mAdc 2N5640		–	30	

*Indicates JEDEC Registered Data.

Note 1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

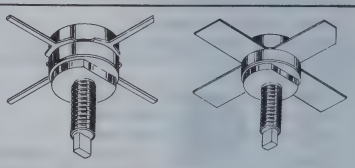
2N5641 (SILICON)
2N5642
2N5643

NPN SILICON RF POWER TRANSISTORS

. . . designed for VHF power amplifier or oscillator applications in military and industrial equipment. These devices are particularly suited for use in Class AB, B, or C amplifier applications to 400 MHz.

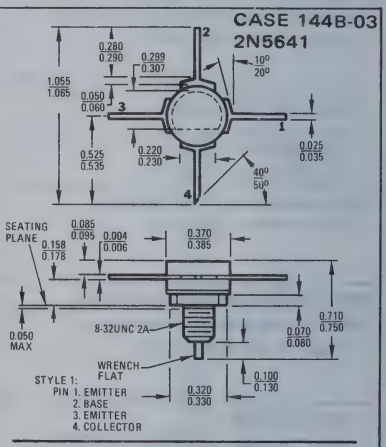
- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.
- Stripline packaging for lower lead inductance and better broadband capability.
- Ceramic Packaging
- Specified 28 Volt, 175 MHz Characteristics –
  2N5641 – 7.0 Watts Output Power at 8.4 dB Gain
  2N5642 – 20 Watts Output Power at 8.2 dB Gain
  2N5643 – 40 Watts Output Power at 7.6 dB Gain

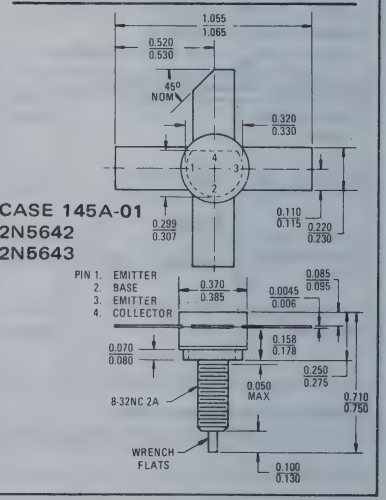
NPN SILICON RF POWER TRANSISTORS



CASE 144B-03 2N5641

CASE 145A-01 2N5642 2N5643





***MAXIMUM RATINGS**

Rating	Symbol	2N5641	2N5642	2N5643	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 65 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current – Continuous	I_C	1.0	3.0	5.0	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	15 86	30 171	60 342	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^oC

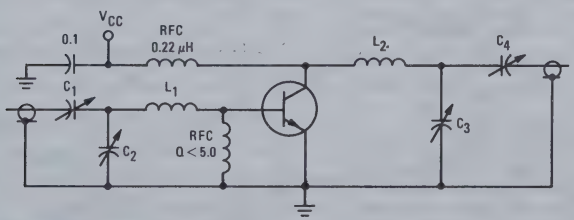
*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)		BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)		BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 5.0 mAdc, I_C = 0)	2N5641		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N5642,2N5643		4.0	–	–	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N5641		5.0	–	–	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	2N5642		5.0	–	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5643		5.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5641		–	8.5	15	
	2N5642		–	22	35	
	2N5643		–	45	65	
FUNCTIONAL TEST						
Power Input (Figure 1)		P_{in}				Watts
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		–	0.4	1.0	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		–	1.9	3.0	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		–	5.0	7.0	
Common-Emitter Amplifier Power Gain (Figure 1)		G_{PE}				dB
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		8.4	12.5	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		8.2	10.2	–	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		7.6	8.1		
Collector Efficiency (Figure 1)		η				%
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		60	–	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		60	–	–	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		60	–	–	

Note 1: Pulsed through 25 mH inductor.
*Indicates JEDEC Registered Data.

FIGURE 1 – 175 MHz TEST CIRCUIT



2N5641	2N5642	2N5643
C_1, C_3, C_4 – 5.0 – 80 pF	C_1 – 3.0 – 30 pF	C_1, C_2, C_3, C_4 - ARCO 464 25-280 pF
C_2 – 9.0 – 180 pF	C_2, C_3, C_4 – 9.0 – 180 pF	L_1 – 1" Straight #14 AWG
L_1 – 1¼" Straight #14 AWG	L_1 – 1" Straight #14 AWG	L_2 – 1 Turn #16 AWG, ¼" I.D.
L_2 – 3 Turns #16 AWG, ¼" I.D.	L_2 – 1 Turn #16 AWG, ¼" I.D.	

TYPICAL PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 2

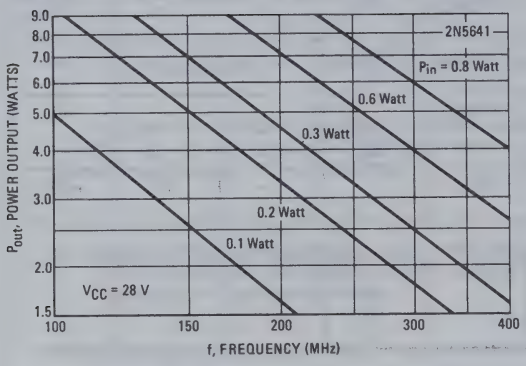


FIGURE 3

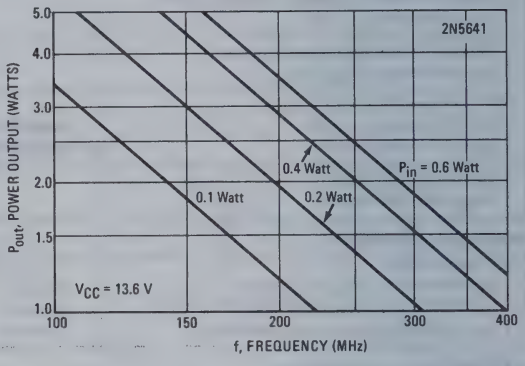


FIGURE 4

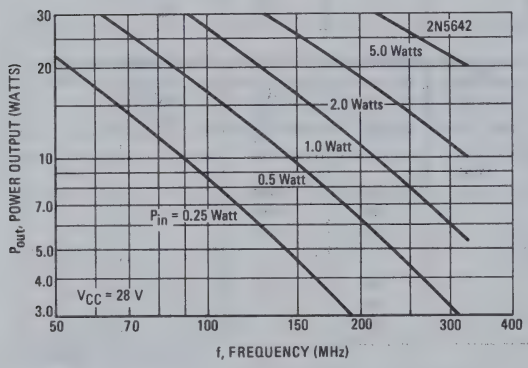


FIGURE 5

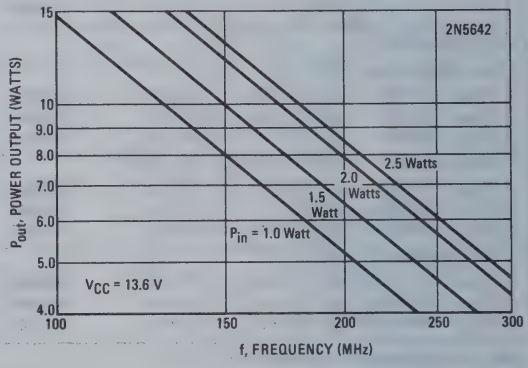


FIGURE 6

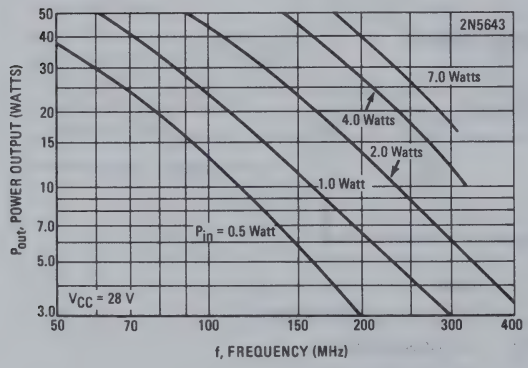
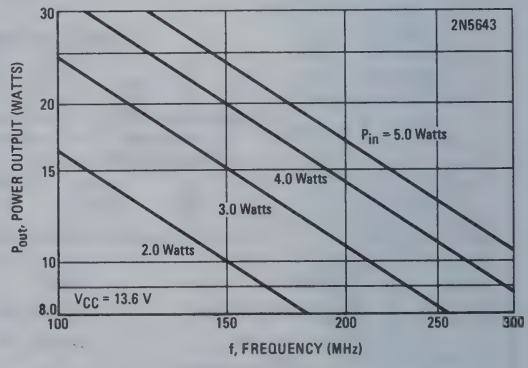


FIGURE 7



TYPICAL PERFORMANCE DATA
POWER OUTPUT versus POWER INPUT

FIGURE 8

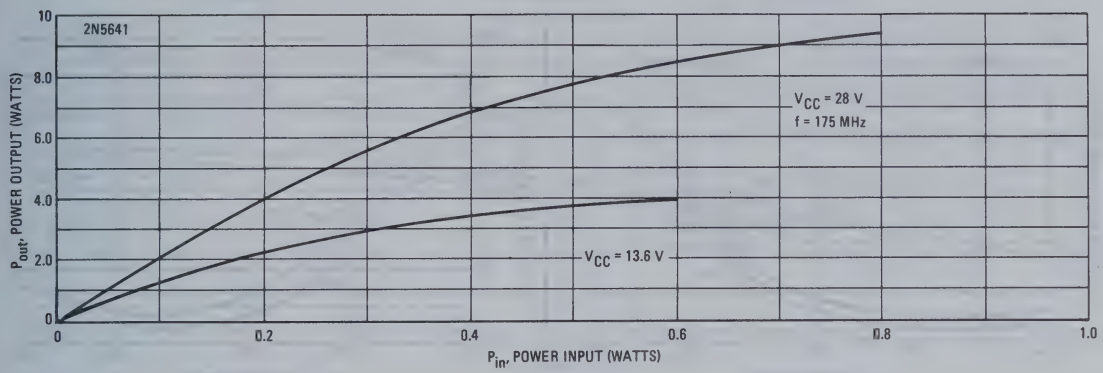


FIGURE 9

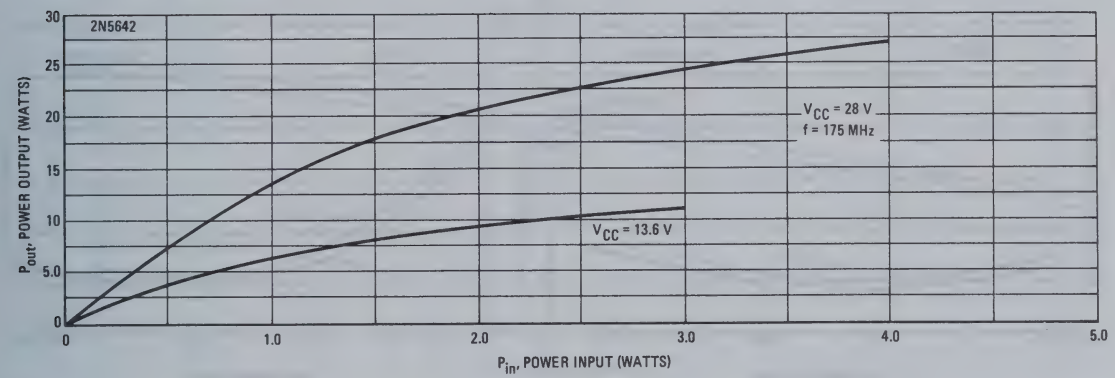
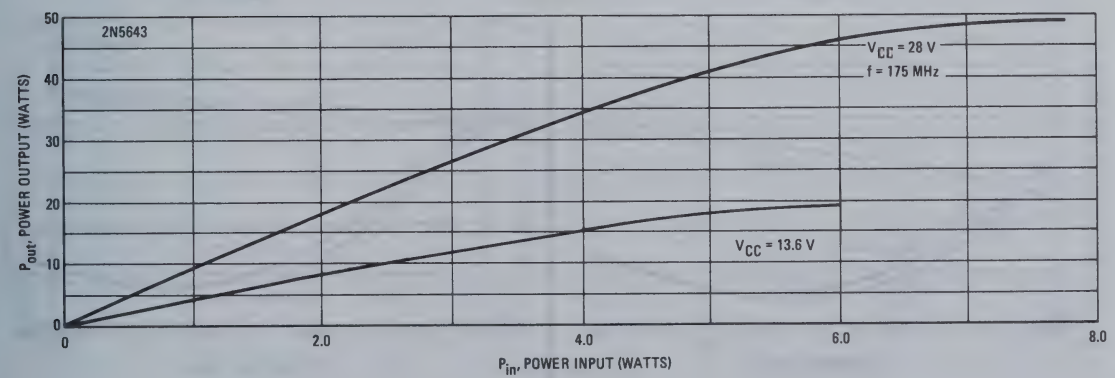


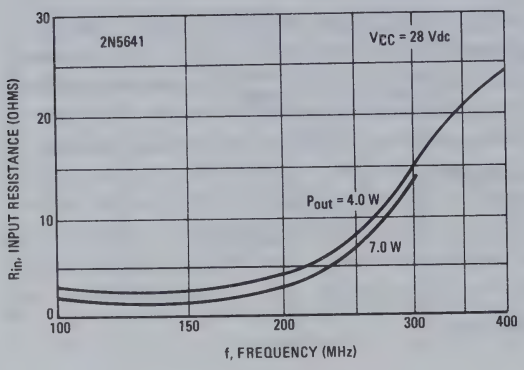
FIGURE 10



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 11



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 12

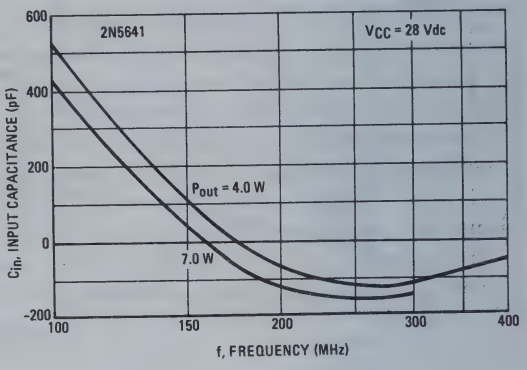


FIGURE 13

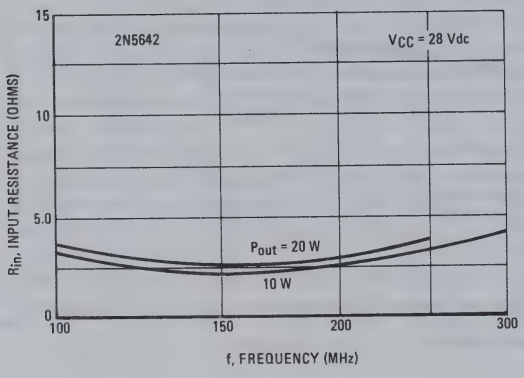


FIGURE 14

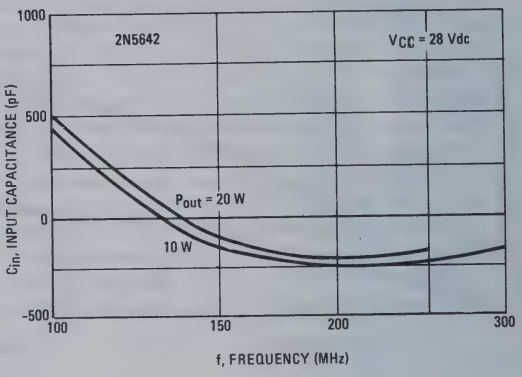


FIGURE 15

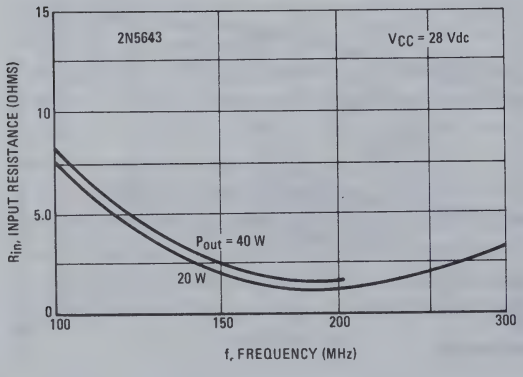
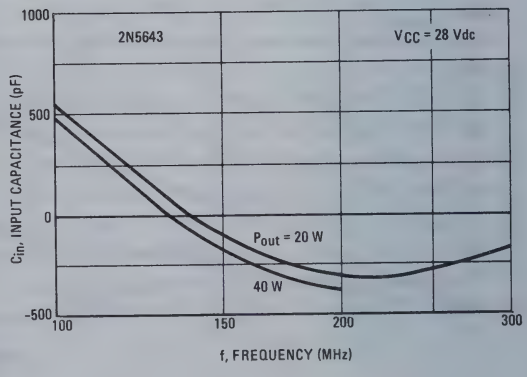


FIGURE 16



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 17

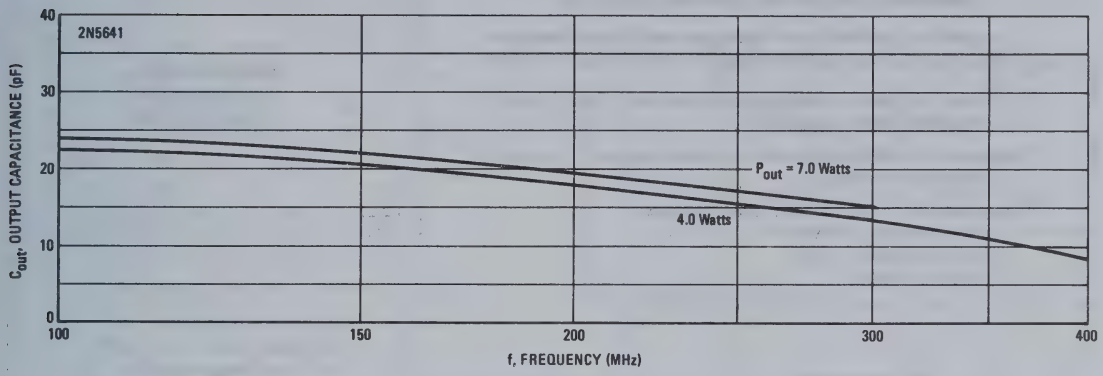


FIGURE 18

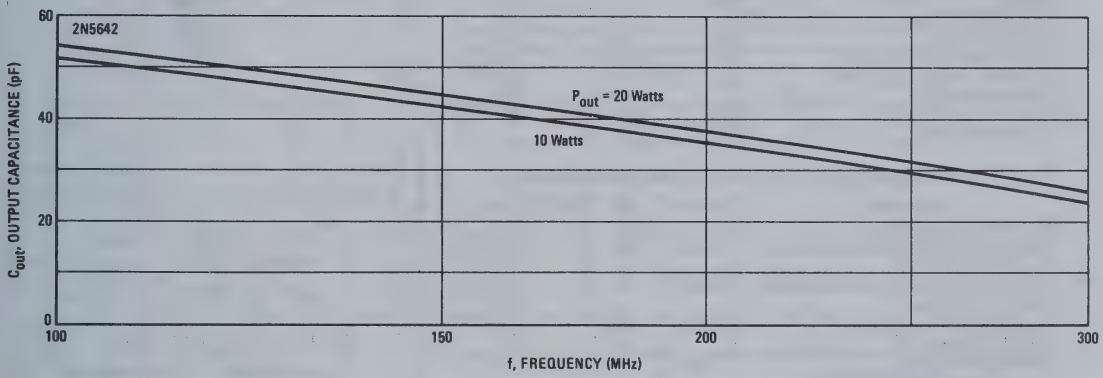
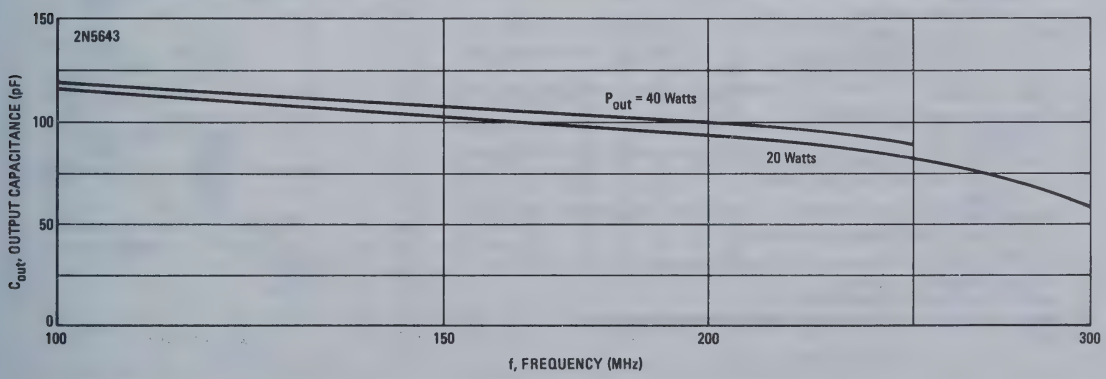


FIGURE 19



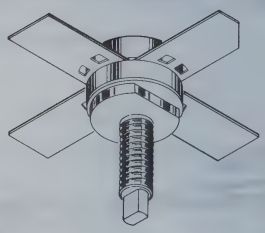
2N5644 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 1.0 Watt
  Minimum Gain = 7.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



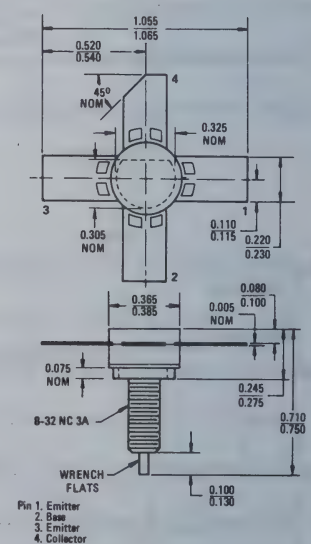
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.25	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3.5 0.02	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (Note 2) (I_C = 50 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	G_{PE}	7.0	–	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	η	60	–	%

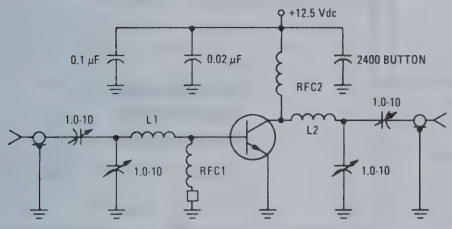
*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A-01

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead.

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

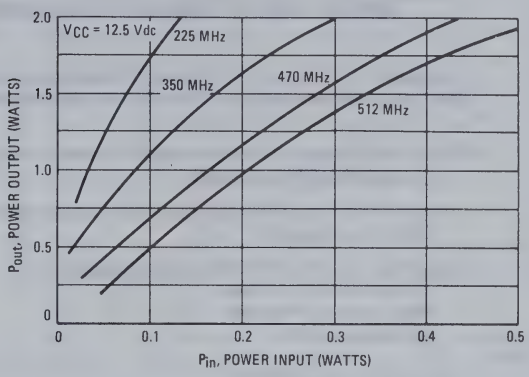


FIGURE 3 – POWER OUTPUT versus FREQUENCY

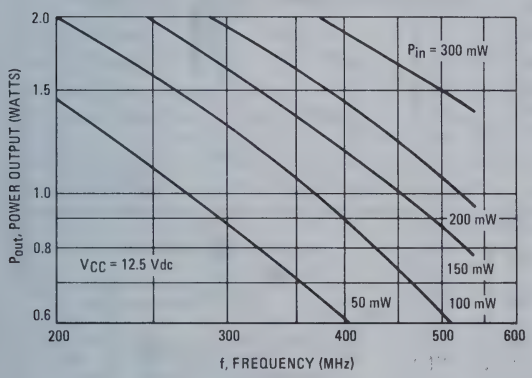


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

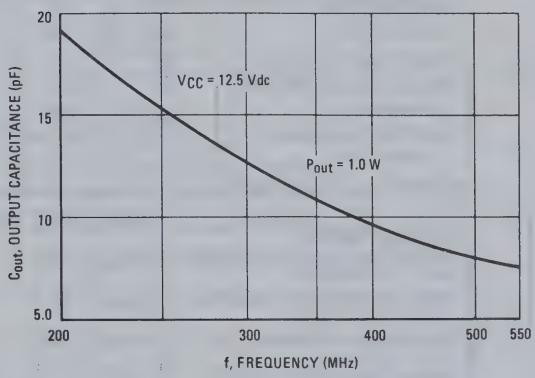


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

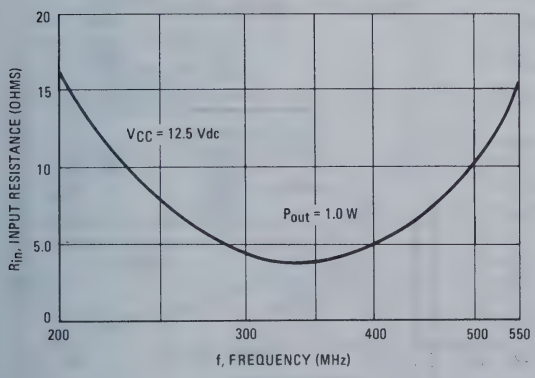
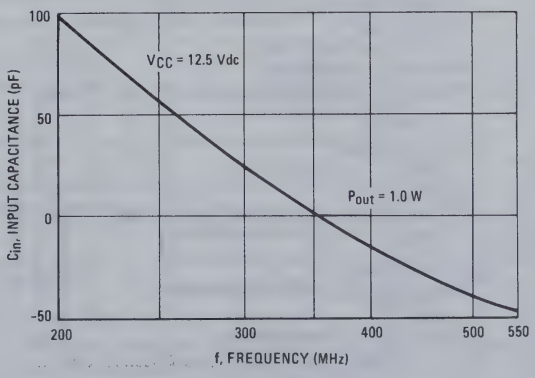


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



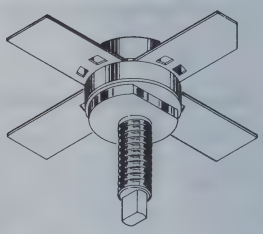
2N5645 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 4.0 Watt
  Minimum Gain = 6.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	12 0.068	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	^oC

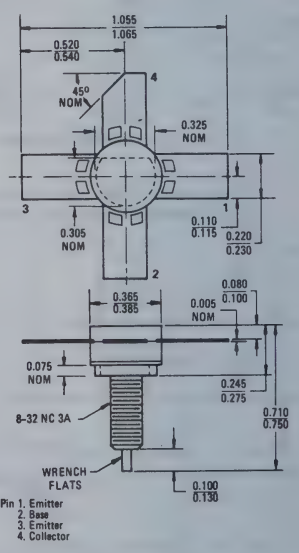
***ELECTRICAL CHARACTERISTICS** ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (Note 2) (I_C = 100 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	20	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	G_{PE}	6.0	–	dB
Collector Efficiency (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	η	60	–	%

*Indicates JEDEC Registered Data.

Note 1: Pulsed through 25 mH inductor.

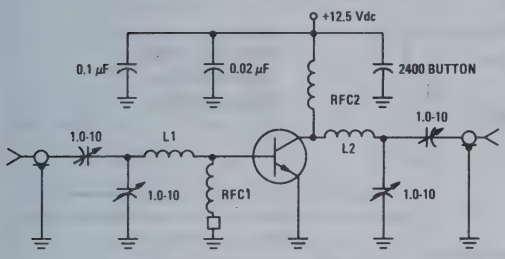
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A–01

DESIGN DATA

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L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

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RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

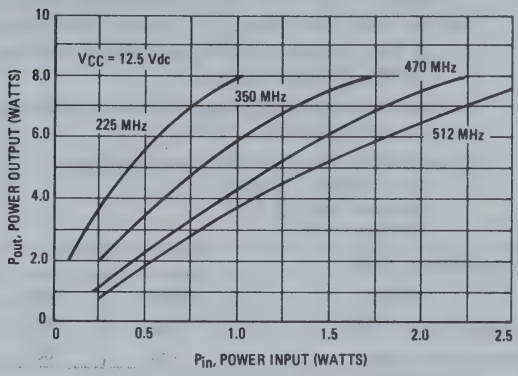


FIGURE 3 – POWER OUTPUT versus FREQUENCY

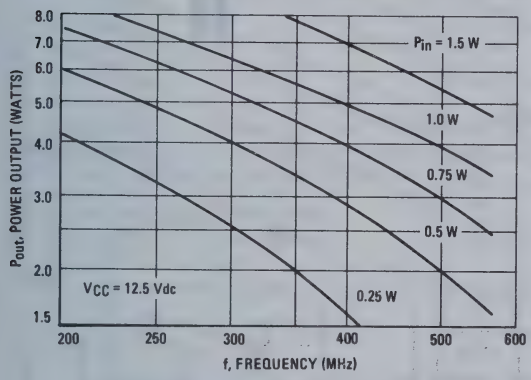


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

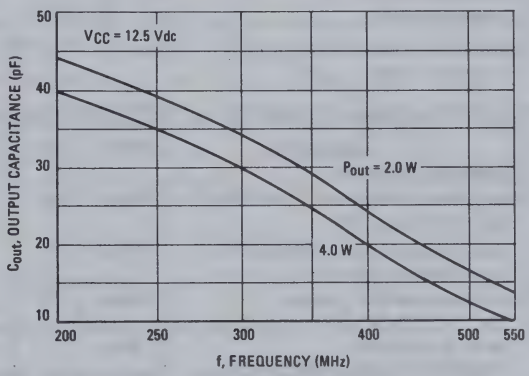


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

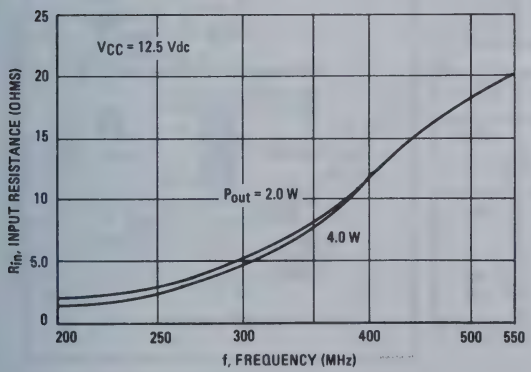
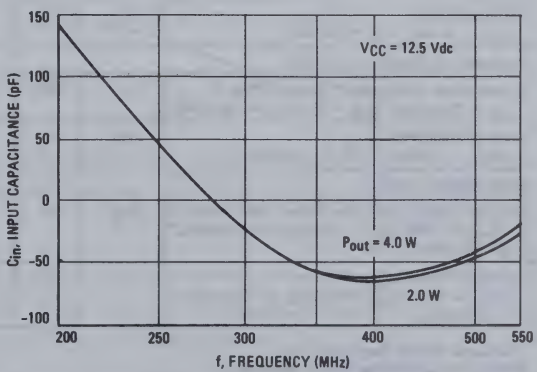


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



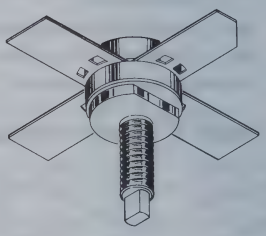
2N5646 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 12 Watt
  Minimum Gain = 4.7 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR

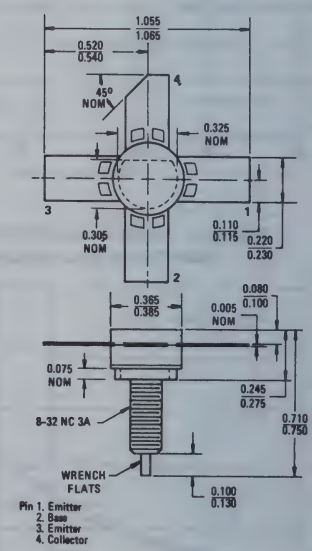


*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	30 0.171	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	—	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	—	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	—	—
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (Note 2) (I_C = 250 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	40	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	G_{PE}	4.7	—	dB
Collector Efficiency (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	η	60	—	%

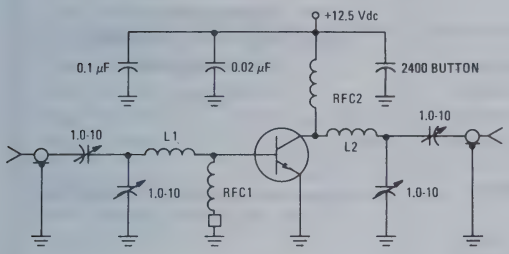


CASE 145A-01

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead.

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

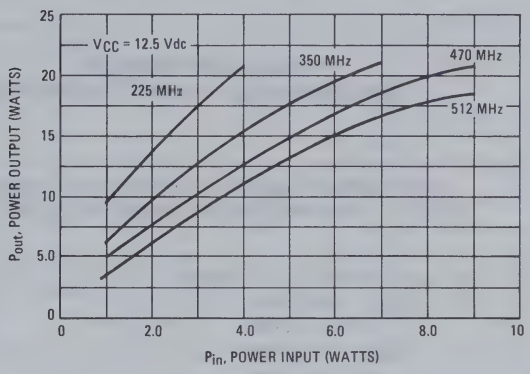


FIGURE 3 – POWER OUTPUT versus FREQUENCY

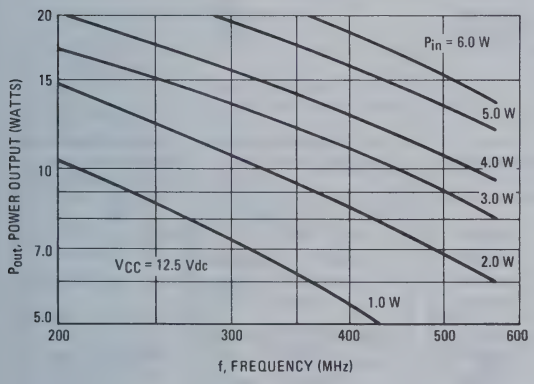


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

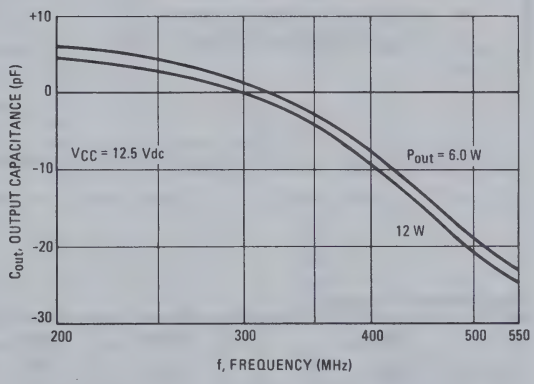


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

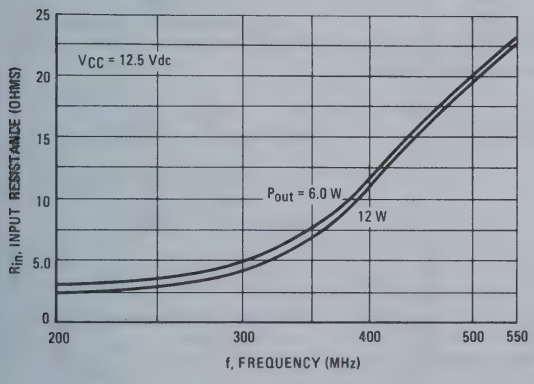
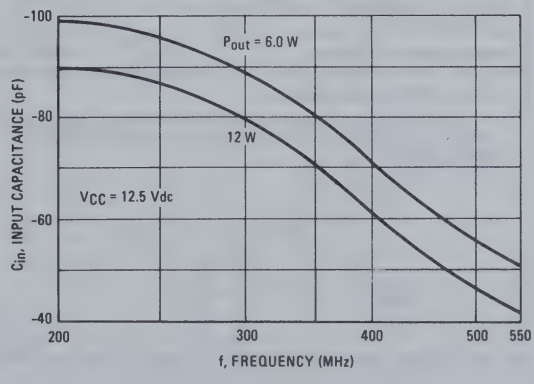


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



2N5653 (SILICON)
2N5654

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power, chopper and switching applications.

- Fast Switching Times — 2N5653
  $t_{d(on)}$ = 4.0 ns (Max)
  t_r = 5.0 ns (Max)
  $t_{d(off)}$ = 5.0 ns (Max)
  t_f = 10 ns (Max)
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 50 Ohms (Max) @ I_D = 1.0 mAdc - 2N5653
- Low Reverse Transfer Capacitance —
  C_{rss} = 3.5 pF (Max) @ V_{GS} = -12 Vdc

N-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS
(Type A)

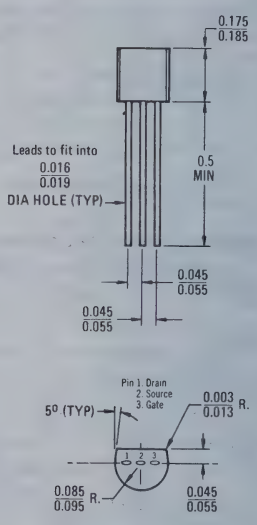


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg} (1)	-65 to +150	°C

*Indicates JEDEC Registered Data.

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

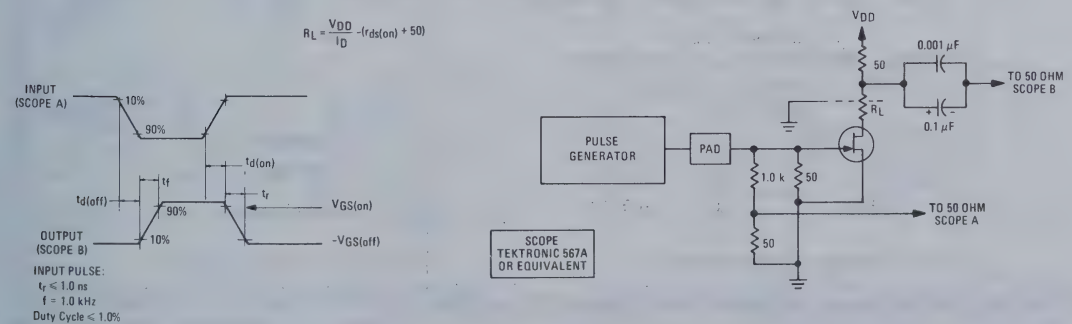
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	Vdc
Gate Reverse Current		I_{GSS}			
(V_{GS} = –15 Vdc, V_{DS} = 0)			–	1.0	nAdc
(V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = –12 Vdc)	2N5653		–	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = –8.0 Vdc)	2N5654		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = –12 Vdc, T_A = 100°C)	2N5653		–	1.0	μAdc
(V_{DS} = 15 Vdc, V_{GS} = –8.0 Vdc, T_A = 100°C)	2N5654		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N5653		40	–	
	2N5654		15	–	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 10 mAdc, V_{GS} = 0)	2N5653		–	0.75	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N5654		–	0.75	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 1.0 mAdc)	2N5653		–	50	
	2N5654		–	100	
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N5653		–	50	
	2N5654		–	100	
Input Capacitance (V_{DS} = 0, V_{GS} = –12 Vdc, f = 1.0 MHz)		C_{iss}	–	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = –12 Vdc, f = 1.0 MHz)		C_{rss}	–	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	Test Condition for 2N5653:				
	(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, 2N5653	$t_{d(on)}$	–	4.0	ns
	$V_{GS(off)}$ = –12 Vdc, 2N5654		–	6.0	
Rise Time	$I_{D(on)}$ = 10 mAdc, 2N5653	t_r	–	5.0	ns
	R_G' = 50 Ohms) 2N5654		–	8.0	
Turn-Off Delay Time	Test Condition for 2N5654:				
	(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, 2N5653	$t_{d(off)}$	–	5.0	ns
	$V_{GS(off)}$ = –12 Vdc, 2N5654		–	10	
Fall Time	$I_{D(on)}$ = 5.0 mAdc, 2N5653	t_f	–	10	ns
	R_G' = 50 Ohms) 2N5654		–	20	
	(Figure 1)				

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2N5655 2N5656 2N5657 (SILICON)
MJE5655 MJE5656 MJE5657

PLASTIC NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

. . . designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays

- Excellent DC Current Gain — h_{FE} = 30-250 @ I_C = 100 mAdc
- Current-Gain — Bandwidth Product — f_T = 10 MHz (Min) @ I_C = 50 mAdc
- Packaged in Thermopad Case for Low Cost
- Choice of Packages — 2N5655, 2N5656, 2N5657 — Case 77
  MJE5655, MJE5656, MJE5657 — Case 199

0.5 AMPERE POWER TRANSISTORS
NPN SILICON
250-300-350 VOLTS
20 and 30 WATTS

*MAXIMUM RATINGS

Rating	Symbol	2N5655 MJE5655	2N5656 MJE5656	2N5657 MJE5657	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	V_{CB}	275	325	375	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current — Continuous	I_C	← 0.5 →			Adc
Peak		← 1.0 →			
Base Current	I_B	← 0.25 →			Adc
		2N5655 Series		MJE5655 Series	
Total Device Dissipation @ T_C = 25°C	P_D	20		30	Watts
Derate above 25°C		0.16		0.24	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5655 Series	MJE5655 Series	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	4.167	°C/W

*Indicates JEDEC Registered Data for 2N5655 Series.

FIGURE 1 — POWER DERATING

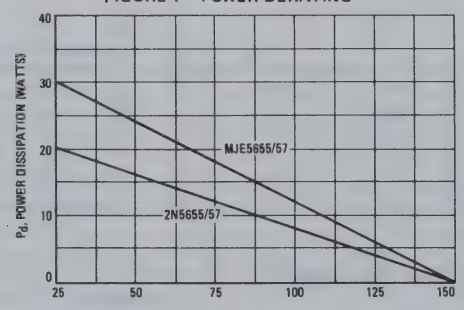
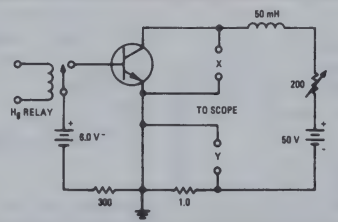
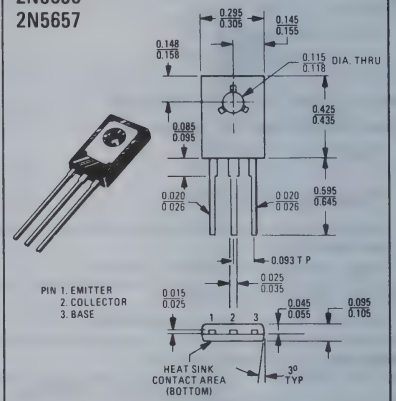


FIGURE 2 — SUSTAINING VOLTAGE TEST CIRCUIT



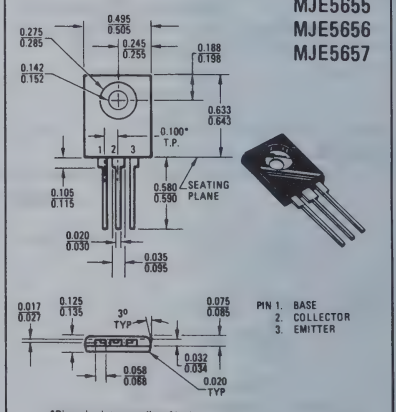
Safe Area Limits are indicated by Figures 3 and 4. Both limits are applicable and must be observed.

2N5655
2N5656
2N5657



CASE 77-03

MJE5655
MJE5656
MJE5657



CASE 199-04

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc (inductive), L = 50 mH)	2N5655, MJE5655	$V_{CEO(sus)}$	250	–	Vdc
	2N5656, MJE5656		300	–	
	2N5657, MJE5657		350	–	
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	2N5655, MJE5655	BV_{CEO}	250	–	Vdc
	2N5656, MJE5656		300	–	
	2N5657, MJE5657		350	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	2N5655, MJE5655		–	0.1	
(V_{CE} = 200 Vdc, I_B = 0)	2N5656, MJE5656		–	0.1	
(V_{CE} = 250 Vdc, I_B = 0)	2N5657, MJE5657		–	0.1	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5655, MJE5655		–	0.1	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5656, MJE5656		–	0.1	
(V_{CE} = 350 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5657, MJE5657		–	0.1	
(V_{CE} = 150 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5655, MJE5655		–	1.0	
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5656, MJE5656		–	1.0	
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5657, MJE5657		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 275 Vdc, I_E = 0)	2N5655, MJE5655			10	
(V_{CB} = 325 Vdc, I_E = 0)	2N5656, MJE5656		–	10	
(V_{CB} = 375 Vdc, I_E = 0)	2N5657, MJE5657		–	10	
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}		10	μAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			25	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			30	250	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			15	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	1.0	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	2.5	
(I_C = 500 mAdc, I_B = 100 mAdc)			–	10	
Base-Emitter Voltage (1) (I_C = 100 mAdc, V_{CE} = 10 Vdc)		V_{BE}	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	10	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	25	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

*Indicates JEDEC Registered Data for 2N5655 Series.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 3 – 2N5655, 2N5656, 2N5657

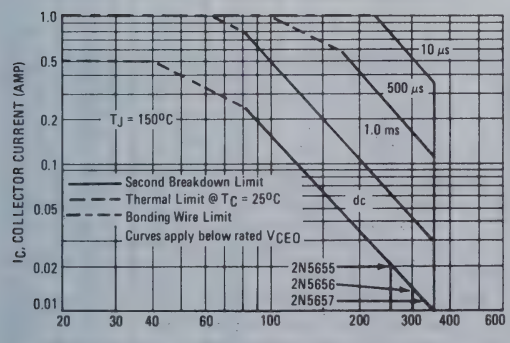
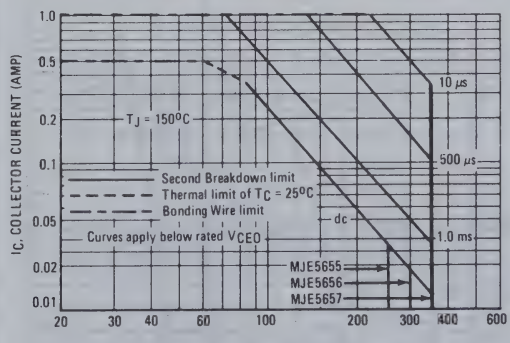


FIGURE 4 – MJE5655, MJE5656, MJE5657

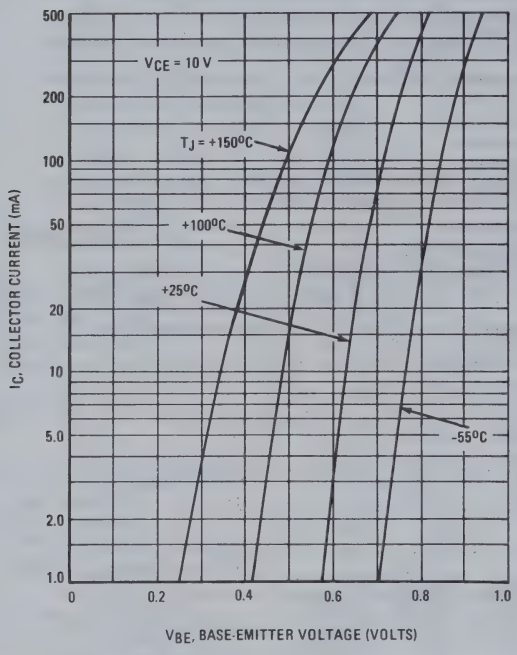


There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 3 and 4 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

LARGE SIGNAL CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE



CUT-OFF CHARACTERISTICS

FIGURE 6 – TRANSCONDUCTANCE

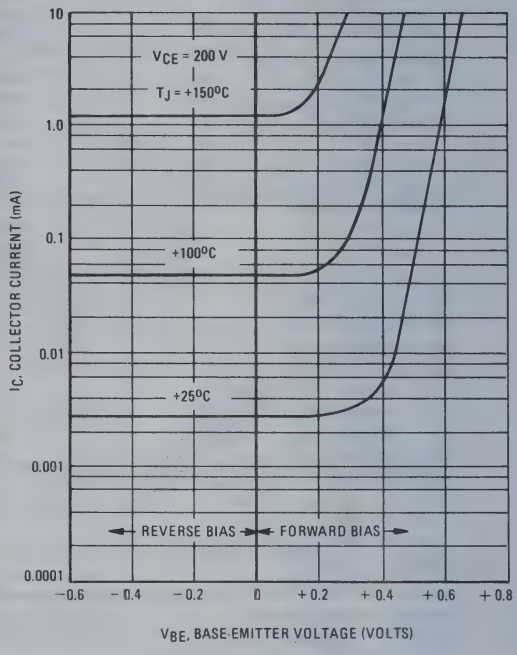


FIGURE 7 – INPUT ADMITTANCE

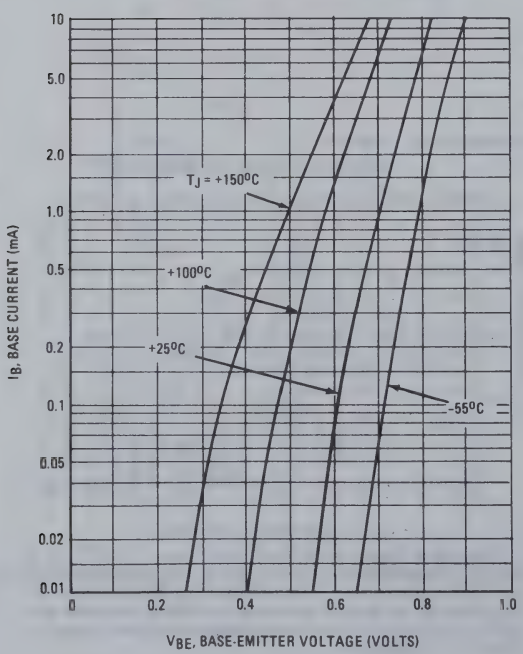


FIGURE 8 – EFFECT OF BASE-EMITTER RESISTANCE

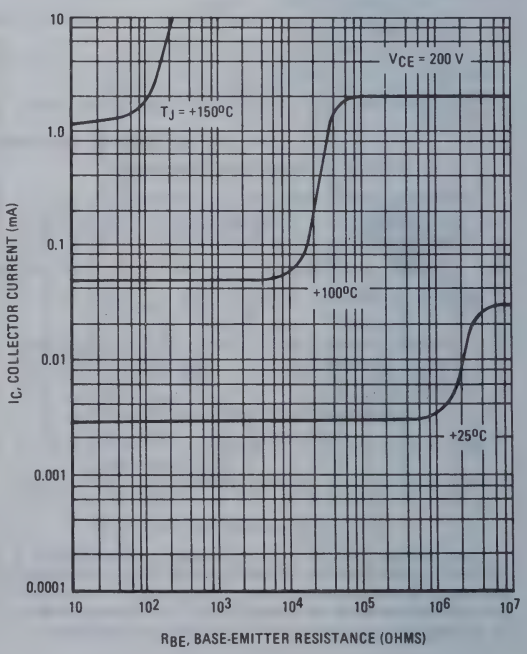


FIGURE 9 – CURRENT GAIN

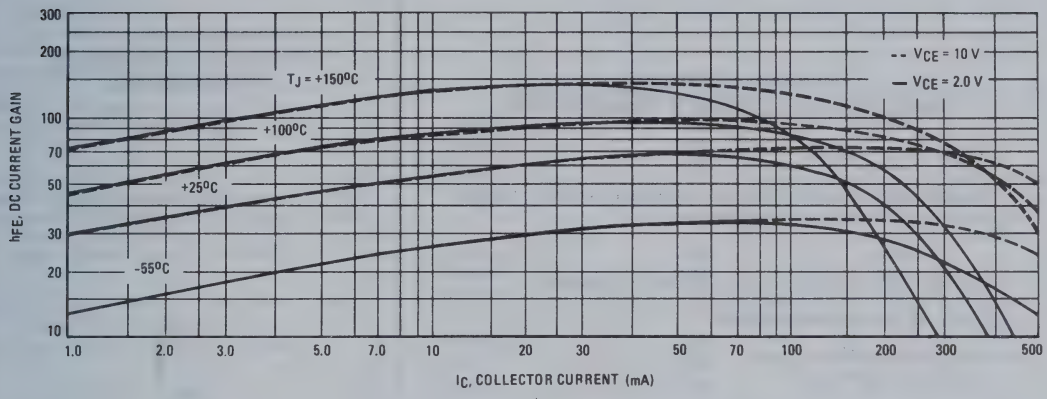


FIGURE 10 – "ON" VOLTAGES

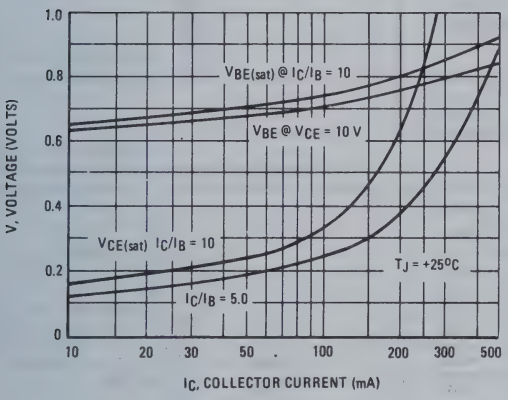


FIGURE 11 – CAPACITANCE

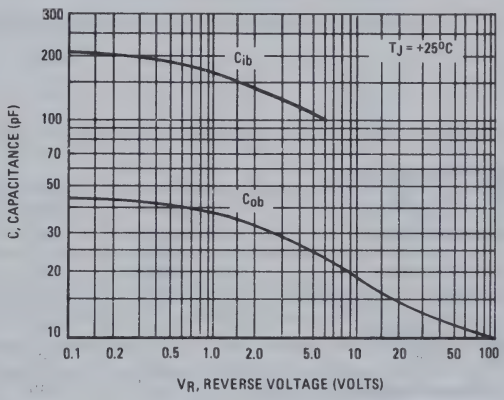


FIGURE 12 – TURN-ON TIME

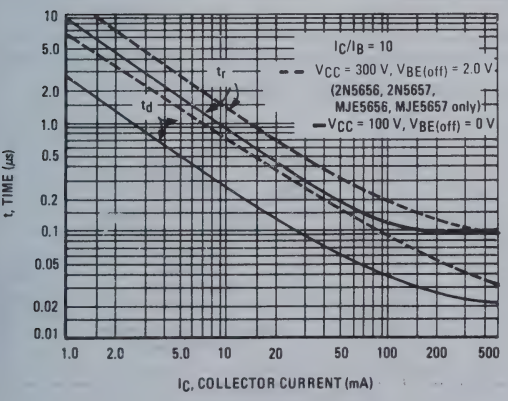
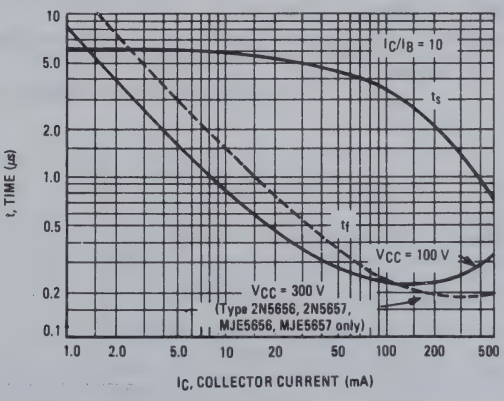


FIGURE 13 – TURN-OFF TIME



2N5668 (SILICON)
2N5669
2N5670

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for VHF amplifier and mixer applications.

- Low Cross Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – NF = 2.5 dB (Max)
- Low Reverse Transfer and Input Capcitances – C_{rss} = 1.0 pF (Typ); C_{iss} = 4.7 pF (Typ)
- High Maximum Stable Gain Due to Drain and Gate Lead Separation

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)

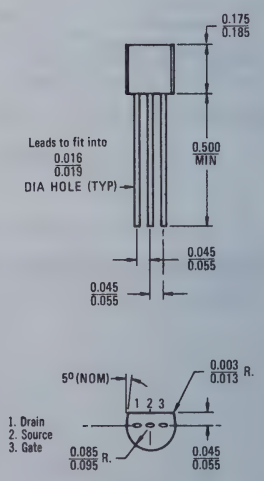


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
*Drain-Gate Voltage	V_{DG}	25	Vdc
*Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
*Forward Gate Current	I_{GF}	10	mAdc
Drain Current	I_D	20	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
*Storage Temperature Range	T_{stg} (1)	-65 to +150	°C

*Indicates JEDEC Registered Data.

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



BOTTOM VIEW
CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

2N5668, 2N5669, 2N5670 (continued)

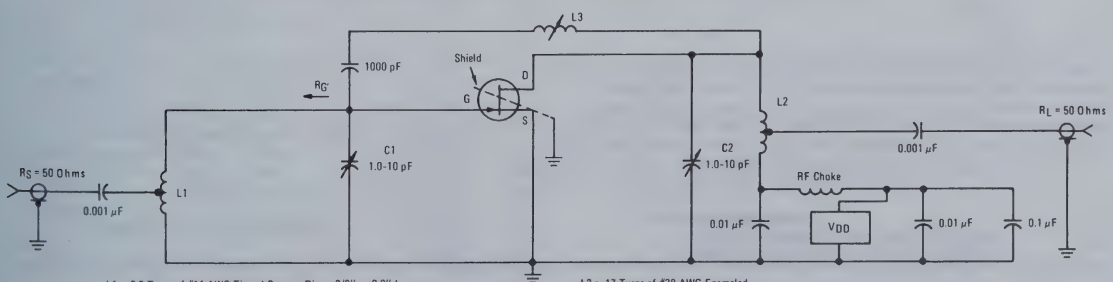
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5668	$V_{GS(off)}$	0.2	–	4.0	Vdc
	2N5669		1.0	–	6.0	
	2N5670		2.0	–	8.0	
Gate Reverse Current		I_{GSS}				
(V_{GS} = –15 Vdc, V_{DS} = 0)			–	–	2.0	nAdc
(V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 100°C)			–	–	2.0	μAdc
***ON CHARACTERISTICS**						
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5668	I_{DSS}	1.0	–	5.0	mAdc
	2N5669		4.0	–	10	
	2N5670		8.0	–	20	
SMALL-SIGNAL CHARACTERISTICS						
*Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5668	$\lvert y_{fs} \rvert$	1500	–	6500	μmhos
	2N5669		2000	–	6500	
	2N5670		3000	–	7500	
*Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5668	$Re(y_{fs})$	1000	–	–	μmhos
	2N5669		1600	–	–	
	2N5670		2500	–	–	
*Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5668	$\lvert y_{os} \rvert$	–	–	20	μmhos
	2N5669		–	–	50	
	2N5670		–	–	75	
*Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5668	$Re(y_{os})$	–	10	50	μmhos
	2N5669		–	25	100	
	2N5670		–	35	150	
*Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	–	125	800	μmhos
*Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	4.7	7.0	pF
*Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.0	3.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	–	1.4	4.0	pF
*Common Source Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz, at R_G = 1.0 k ohm)		NF	–	–	2.5	dB
Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		G_{ps}	16	–	–	dB

*Indicates JEDEC Registered Data, excluding typical values.

Note 1: Pulse Test: Pulse With = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 – 100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



L1 ≈ 8.5 Turns of #14 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 0.9" Long. Tapped at ≈ 2-1/2 Turns (adjust to give R_G = 1.0 k ohm); Parallel Resistance = 40 k ohms; tunes at ≈ 8.0 pF.

L2 ≈ 13.5 Turns #16 AWG Tinned Copper; Dia. ≈ 3/8", ≈ 1.2" Long. Tapped at ≈ 5 Turns; Parallel Resistance = 40 k ohms; tunes at ≈ 4.0 pF.

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug.

2N5679 (SILICON)
2N5680

LOW-POWER PNP SILICON TRANSISTORS

. . . designed for use as a driver for high-power transistors in general-purpose amplifier and switching circuit applications.

- High Current-Gain–Bandwidth Product – f_T = 30 MHz (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 0.25 Adc
- DC Current Gain Bracketed at 0.25 Adc
- Complement to NPN 2N5681 and 2N5682

1 AMPERE
POWER TRANSISTORS
PNP SILICON

100-120 VOLTS
10 WATTS



*MAXIMUM RATINGS

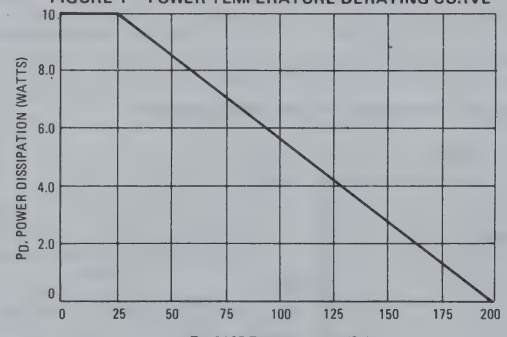
Rating	Symbol	2N5679	2N5680	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Base Current	I_B	0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 0.0057		Watt W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

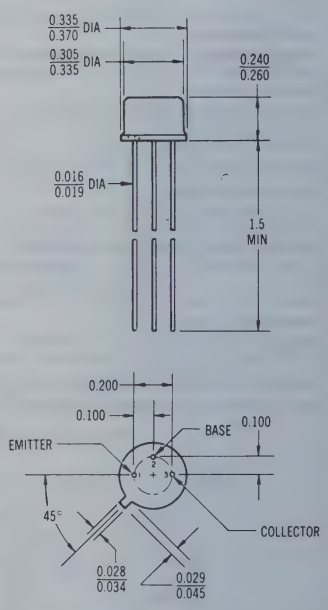
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.



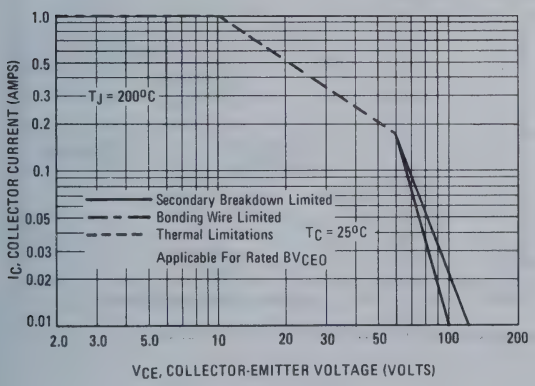
CASE 31 (1)
TO-5
Collector Connected to Case

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N5679	$V_{CEO(sus)}$	100	–	Vdc
	2N5680		120	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 70 Vdc, I_B = 0)			–	10	
(V_{CE} = 80 Vdc, I_B = 0)			–	10	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5679		–	1.0	μAdc
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5680		–	1.0	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5679		–	1.0	mAdc
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5680		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5679		–	1.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N5680		–	1.0	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 2.0 Vdc)			40	150	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.6	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	
(I_C = 1.0 Adc, I_B = 200 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	–
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5681 (SILICON)
2N5682

LOW-POWER NPN SILICON TRANSISTORS

. . . designed for use as a driver for high-power transistors in general-purpose amplifier and switching circuit applications.

- High Current-Gain—Bandwidth Product — f_T = 30 MHz (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 0.25 Adc
- DC Current Gain Bracketed at 0.25 Adc
- Complement to PNP 2N5679 and 2N5680

1 AMPERE
POWER TRANSISTORS
NPN SILICON
100-120 VOLTS
10 WATTS



*MAXIMUM RATINGS

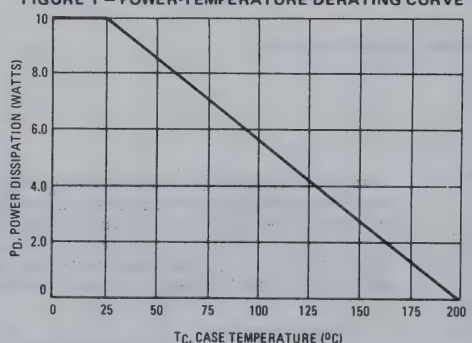
Rating	Symbol	2N5681	2N5682	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Base Current	I_B	0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 0.0057		Watt W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

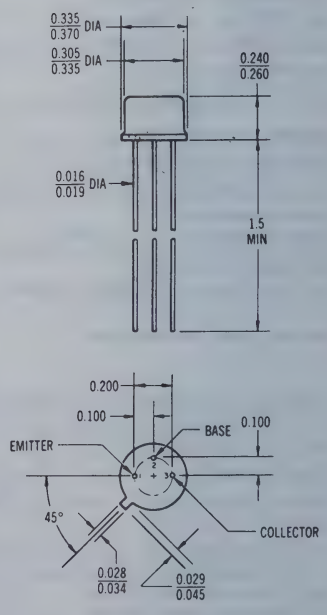
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.



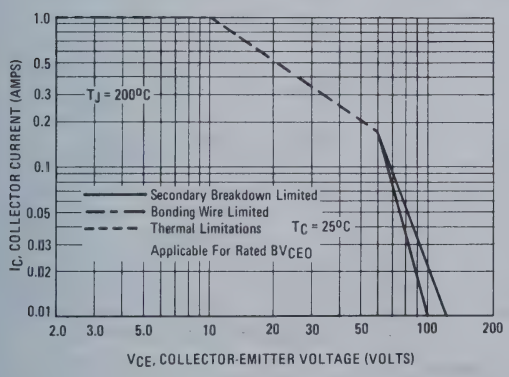
CASE 31 (1)
TO 5
Collector Connected to Case

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N5681	$V_{CEO(sus)}$	100	–	Vdc
	2N5682		120	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 70 Vdc, I_B = 0)			–	10	
(V_{CE} = 80 Vdc, I_B = 0)			–	10	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5681		–	1.0	μAdc
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5682		–	1.0	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5681		–	1.0	mAdc
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5682		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5681		–	1.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N5682		–	1.0	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 2.0 Vdc)			40	150	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.6	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	
(I_C = 1.0 Adc, I_B = 200 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5683, 2N5684 PNP (SILICON)
2N5685, 2N5686 NPN

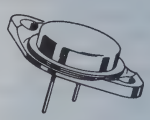
HIGH-CURRENT COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for use in high-power amplifier and switching circuit applications.

- High Current Capability – I_C Continuous = 50 Amperes.
- DC Current Gain – h_{FE} = 15 - 60 @ I_C = 25 Adc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc

50 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60–80 VOLTS
300 WATTS



*MAXIMUM RATINGS

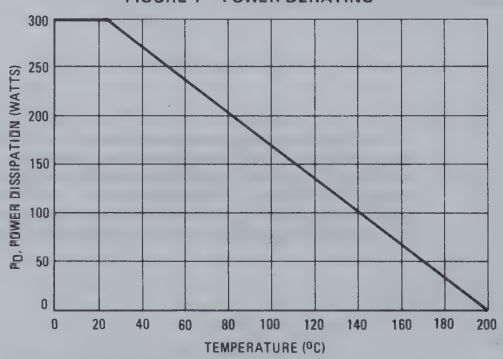
Rating	Symbol	2N5683 2N5685	2N5684 2N5686	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		Adc
Base Current	I_B	15		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.715		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*THERMAL CHARACTERISTICS

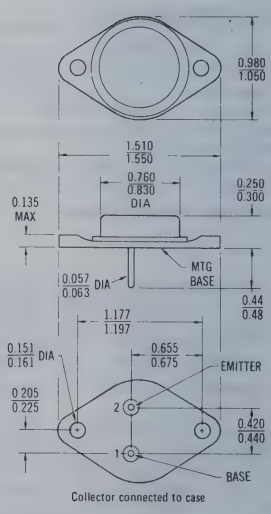
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.584	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



CASE 197
TO-3 Except Pin Diameter

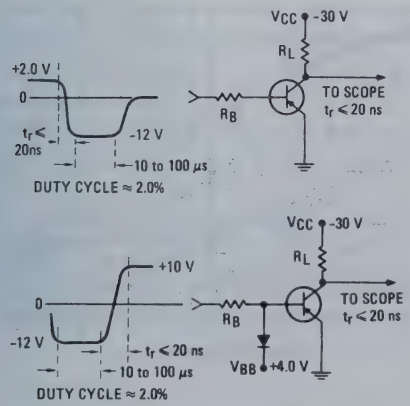
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	2N5683, 2N5685		60	–	
	2N5684, 2N5686		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5683, 2N5685		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5684, 2N5686		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5683, 2N5685		–	2.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5684, 2N5686		–	2.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5683, 2N5685		–	10	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5684, 2N5686		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5683, 2N5685		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5684, 2N5686		–	2.0	
Emitter Cutoff Current		I_{EBO}	–	5.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			15	60	
(I_C = 50 Adc, V_{CE} = 5.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)			–	1.0	
(I_C = 50 Adc, I_B = 10 Adc)			–	5.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	2.0	Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)					
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	2.0	Vdc
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	2.0	–	MHz
(I_C = 5.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)					
Output Capacitance	2N5683, 2N5684	C_{ob}	–	2000	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N5685, 2N5686		–	1200	
Small-Signal Current Gain		h_{fe}	15	–	
(I_C = 10 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 & 6, R_B & R_L ARE VARIED.
INPUT LEVELS ARE APPROXIMATELY AS SHOWN.
FOR NPN CIRCUITS, REVERSE ALL POLARITIES.

FIGURE 3 – TURN-ON TIME

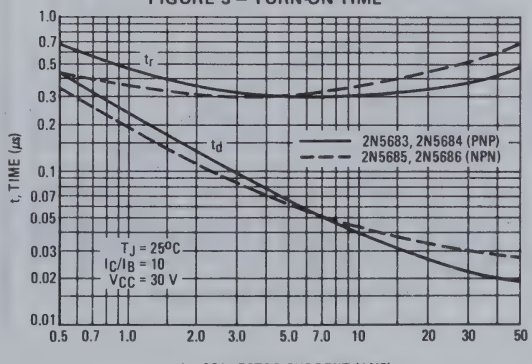


FIGURE 4 – THERMAL RESPONSE

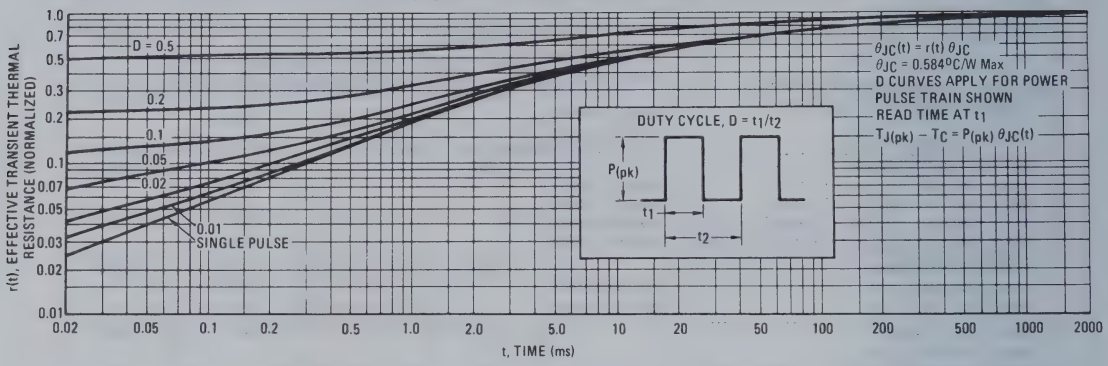
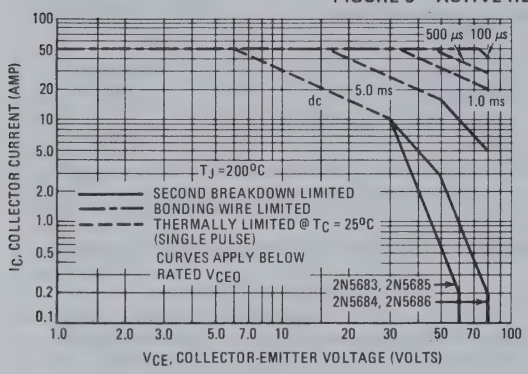


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

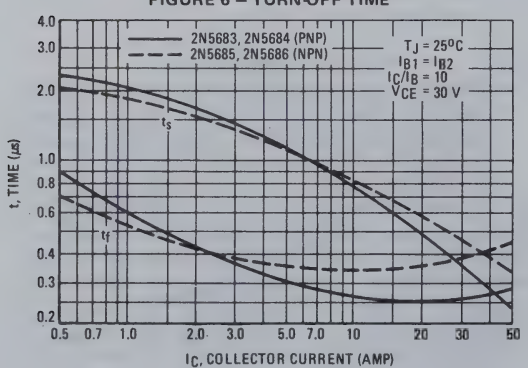
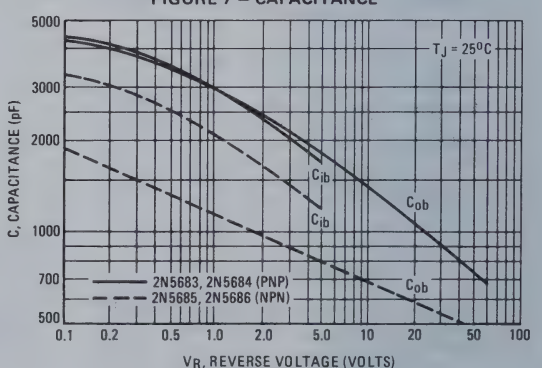


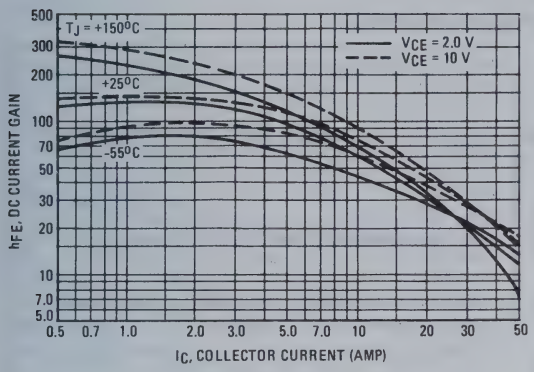
FIGURE 7 – CAPACITANCE



PNP
2N5683, 2N5684

NPN
2N5685, 2N5686

FIGURE 8 – DC CURRENT GAIN



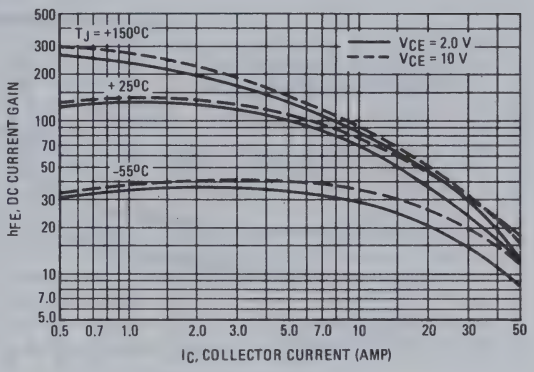
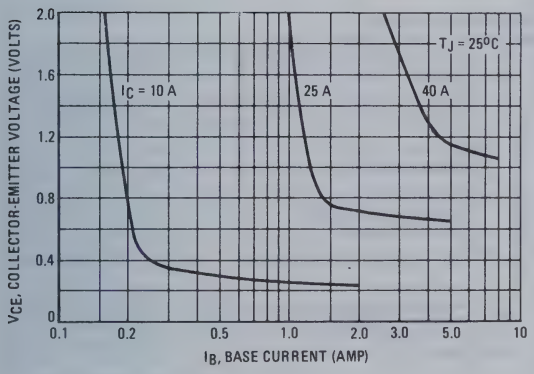


FIGURE 9 – COLLECTOR SATURATION REGION



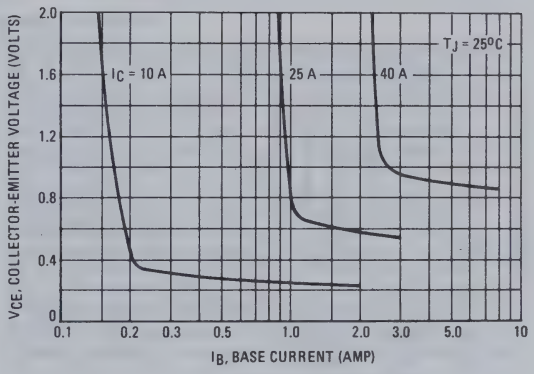
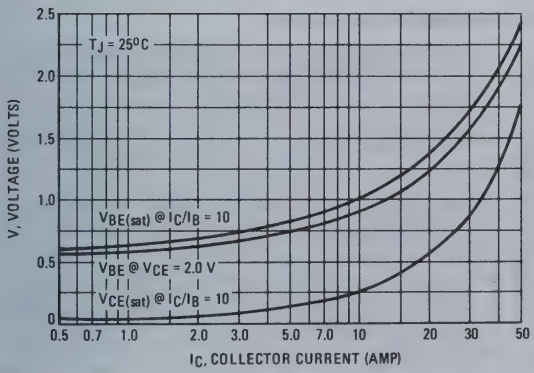
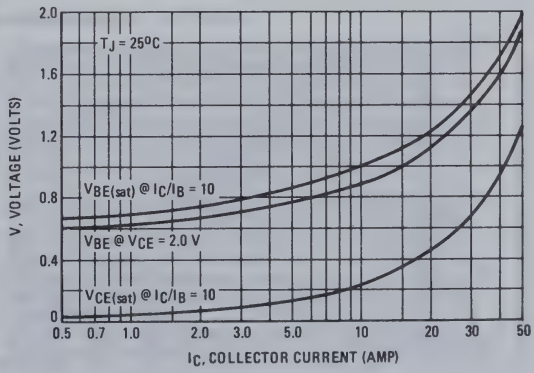


FIGURE 10 – "ON" VOLTAGES

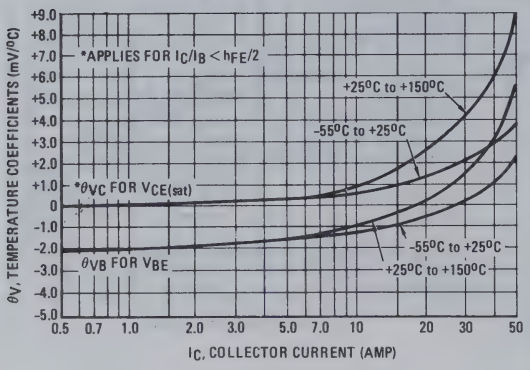




PNP
2N5683, 2N5684

NPN
2N5685, 2N5686

FIGURE 11 – TEMPERATURE COEFFICIENTS



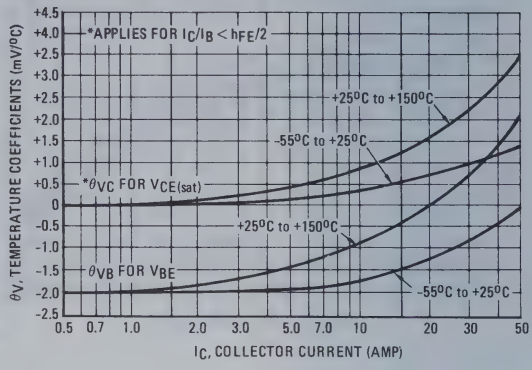
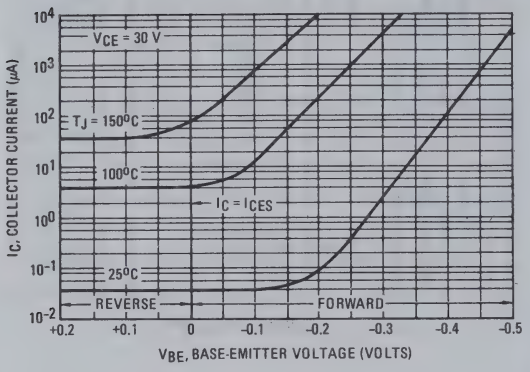


FIGURE 12 – COLLECTOR CUTOFF REGION



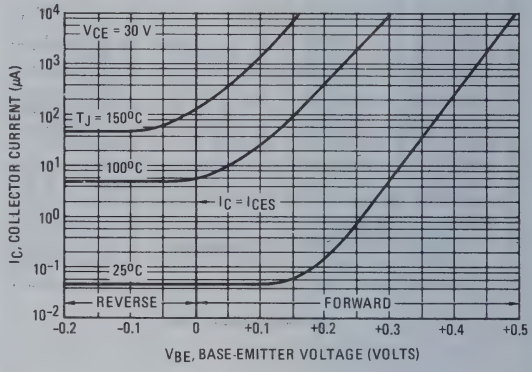
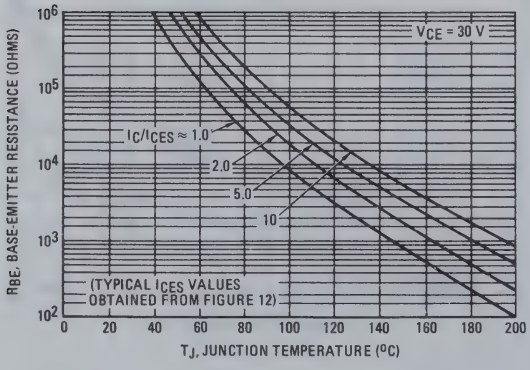
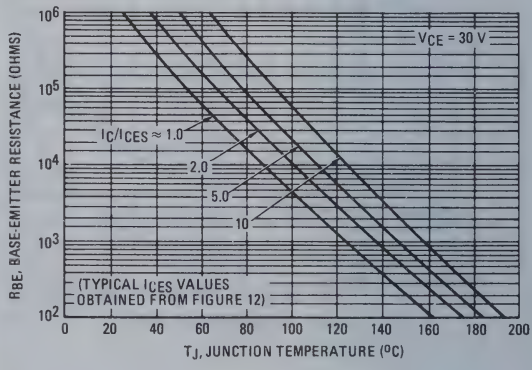


FIGURE 13 – EFFECT OF EXTERNAL BASE-EMITTER RESISTANCE





2N5692 thru 2N5696 (GERMANIUM)

PNP GERMANIUM POWER SWITCHING TRANSISTORS

. . . designed for high-current, fast-switching applications requiring low saturation voltage and excellent safe operating area.

40 AMPERE "ADE" POWER TRANSISTORS
PNP GERMANIUM
50–140 VOLTS
120 WATTS



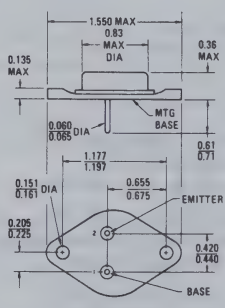
MAXIMUM RATINGS

Rating	Symbol	2N5692	2N5693	2N5694	2N5695	2N5696	Unit
*Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
*Collector-Base Voltage	V_{CB}	50	80	100	120	140	Vdc
*Emitter-Base Voltage	V_{EB}	2.5					Vdc
*Collector Current — Continuous	I_C	40					Adc
— Peak		60					
*Base Current — Continuous	I_B	12					Adc
*Total Device Dissipation @ $T_C = 25^oC$	P_D	120					Watts
Derate above 25^oC		1.43					$W/^oC$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +110					^oC

THERMAL CHARACTERISTICS

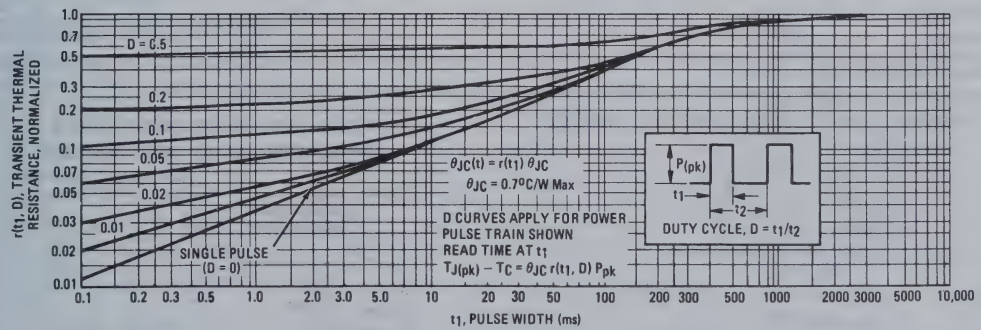
Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.7	$^oC/W$

*Indicates JEDEC Registered Data.



CASE 3A
(TO-3)
Collector Connected to Case

FIGURE 1 – THERMAL RESPONSE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
* Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5692	BV_{CEO}	30	–	Vdc
	2N5693		60	–	
	2N5694		80	–	
	2N5695		100	–	
	2N5696		120	–	
* Collector Cutoff Current (V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc	2N5692	I_{CEX1}	–	10	mAdc
(V_{CE} = 80 Vdc)	2N5693		–	10	
(V_{CE} = 100 Vdc) For	2N5694		–	10	
(V_{CE} = 120 Vdc) All Types	2N5695		–	10	
(V_{CE} = 140 Vdc)	2N5696		–	10	
* Collector Cutoff Current (V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C	2N5692	I_{CEX2}(1)	–	30	mAdc
(V_{CE} = 80 Vdc) For	2N5693		–	30	
(V_{CE} = 100 Vdc)	2N5694		–	30	
(V_{CE} = 120 Vdc) All Types	2N5695		–	30	
(V_{CE} = 140 Vdc)	2N5696		–	30	
* Collector-Emitter Sustaining Voltage (See Figure 3)		$V_{CEX(sus)}$			Vdc
(I_C = 10 Adc)	2N5692		50	–	
	2N5693		80	–	
	2N5694		100	–	
	2N5695		120	–	
	2N5696		140	–	
(I_C = 40 Adc)	2N5692		45	–	
	2N5693		50	–	
	2N5694		55	–	
	2N5695		60	–	
	2N5696		65	–	
* Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	200	μAdc
* Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	500	mAdc
ON CHARACTERISTICS (1)					
* DC Current Gain (I_C = 25 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	65	–
(I_C = 40 Adc, V_{CE} = 2.0 Vdc)			10	–	
* Collector-Emitter Saturation Voltage (I_C = 60 Adc, I_B = 12 Adc)		$V_{CE(sat)}$ [1]	–	0.75	Vdc
* Base-Emitter Saturation Voltage (I_C = 60 Adc, I_B = 12 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
* Current-Gain—Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	200	–	kHz
SWITCHING CHARACTERISTICS					
* Rise Time	(I_C = 25 Adc, I_{B1} = 2.5 Adc, I_{B2} = 2.5 Adc) (See Figure 2)	t_r	–	20	μs
* Storage Time		t_s	–	8.0	μs
* Fall Time		t_f	–	15	μs

*Indicates JEDEC Registered Data.

(1) To avoid excessive heating of the collector junction, perform test with pulse method. (PW ≤ 300 μs, DC ≤ 2.0%).

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

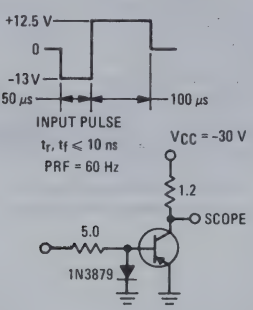
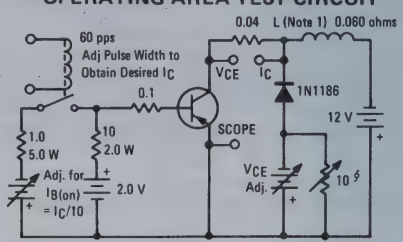


FIGURE 3 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT



ϕ Set to allow reverse surge current to by pass power supply. Not needed for power supply with low reverse impedance.

NOTE 1: L = 10 mH at I_C = 10 A
L = 0.25 mH at I_C = 40 A

2N5716 (SILICON)
2N5717
2N5718

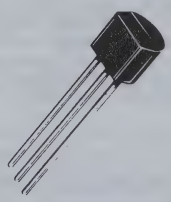
SILICON LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode Junction Field-Effect Transistors designed for audio amplifiers in low-power or battery operated applications.

- Low Zero-Gate-Voltage Drain Current @ V_{DS} = 15 Vdc –
  I_{DSS} = 50 μAdc to 250 μAdc – 2N5716
  200 μAdc to 1.0 mAdc – 2N5717
  800 μAdc to 4.0 mAdc – 2N5718
- High Forward Transadmittance @ V_{DS} = 15 Vdc, f = 1.0 kHz –
  $|Y_{fs}|$ = 350 μmhos (Typ) @ I_D = 50 μAdc – 2N5716
  550 μmhos (Typ) @ I_D = 200 μAdc – 2N5717
  900 μmhos (Typ) @ I_D = 800 μAdc – 2N5718
- Low Noise Voltage –
  e_n = 75 nV/$\sqrt{Hz}$ (Max) @ f = 1.0 kHz
- Drain and Source Interchangeable

LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

e_n = 75 nV/$\sqrt{Hz}$



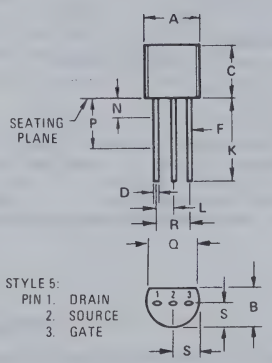
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Operating Channel Temperature	$T_{channel}$	150	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS:

Maximum Lead Temperature for Soldering:
240°C, not less than 1/16" from case for 10 s.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Gate-Drain Breakdown Voltage (I_D = 1.0 μAdc, I_S = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	2N5716	$V_{GS(off)}$	0.2	3.0	Vdc
	2N5717		0.5	5.0	
	2N5718		1.0	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	–	1.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
***ON CHARACTERISTICS**					
Zero-Gate Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5716	I_{DSS}	0.05	0.25	mAdc
	2N5717		0.2	1.0	
	2N5718		0.8	4.0	
SMALL-SIGNAL CHARACTERISTICS					
*Forward Transadmittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5716	$\lvert y_{fs}\rvert$	200	1000	μmhos
	2N5717		400	1600	
	2N5718		500	2000	
*Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		$\lvert y_{os}\rvert$	–	25	μmhos
*Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	5.0	pF
*Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)		e_n	–	75	$nV/\sqrt{Hz}$

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

TYPICAL SMALL-SIGNAL CHARACTERISTICS

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

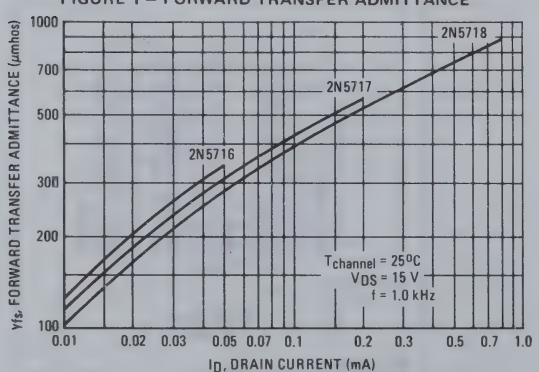
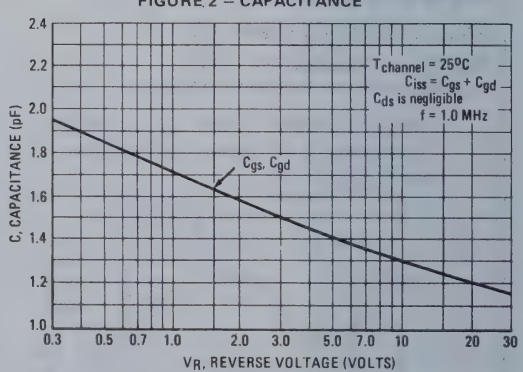
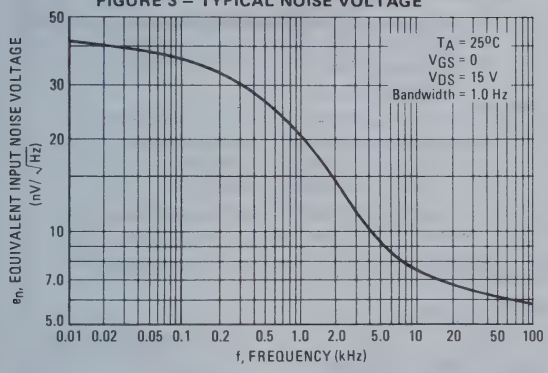


FIGURE 2 – CAPACITANCE



NOISE DATA

FIGURE 3 – TYPICAL NOISE VOLTAGE



In a junction field-effect transistor, the current flow is due to carrier drift, therefore total noise at the input may be expressed as:

$$V_T = [\, e^2_n + 4\,KT\,R_S \,]^{1/2}$$

where V_T = total noise voltage at the FET input (volts/$\sqrt{Hz}$)
e_n = noise voltage of the FET referred to the input (Figure 3).
K = Boltzman's constant (1.38×10^{-23} j/°K)
T = temperature of the source resistance (°K)
R_S = source resistance (ohms)

Example:

Find the total noise at the input of a 2N5716 FET with a source impedance of 10 kilohms at a frequency of 1.0 kHz and at a temperature of 25°C.

Read e_n = 20.5 nV/$\sqrt{Hz}$ from Figure 3. (Note that this is for a one cycle bandwidth).

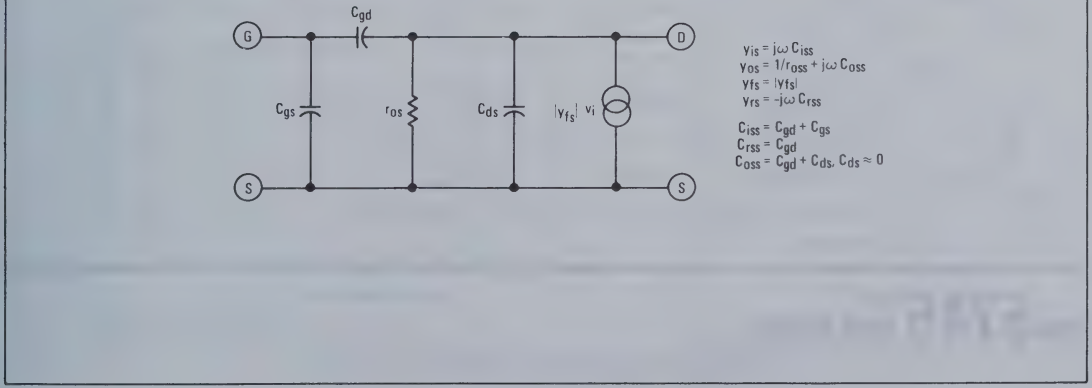
$V_T = [(20.5\times10^{-9})^2 + (4)(1.38\times10^{-23}\,(300)(1\times10^4)]^{1/2}$
$= 24.2$ nV/$\sqrt{Hz}$

Noise over a frequency band can be handled in one of two ways depending upon whether FET noise is constant or variable over the bandwidth of interest:

1. For constant FET noise, multiply V_T by the square root of bandwidth, i.e., $V'_T = V_T \bullet \Delta f^{1/2}$
2. For variable FET noise, plot V'_T (where Δf = 1.0 Hz) versus frequency over the bandwidth and integrate the result.

Total noise voltage at the output of the FET stage can be found by multiplying V_T by the voltage gain of the stage.

FIGURE 4 – LOW FREQUENCY CIRCUIT MODEL



TYPICAL LIMIT TRANSFER CHARACTERISTICS

(Temperatures Noted are $T_{channel}$)

FIGURE 5 – 2N5716

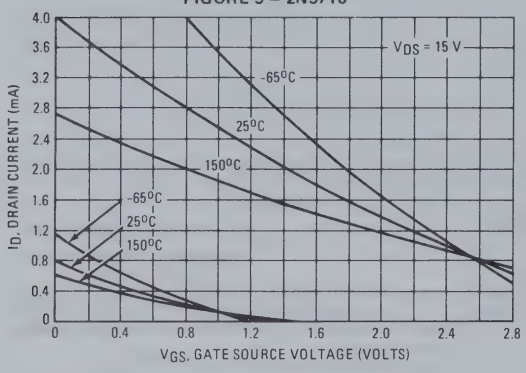


FIGURE 6 – 2N5717

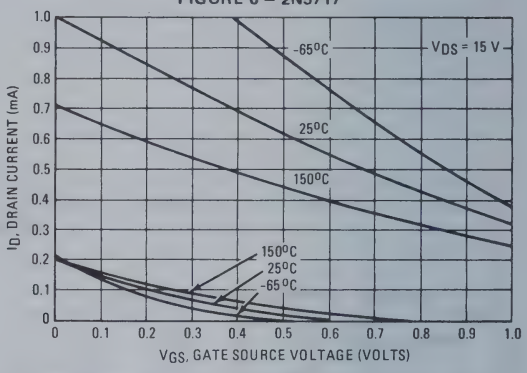


FIGURE 7 – 2N5718

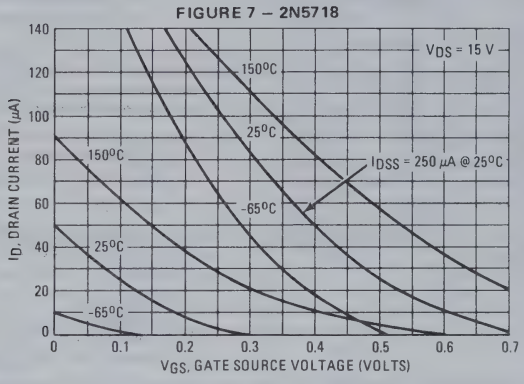
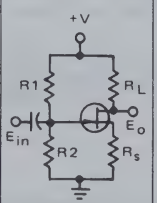
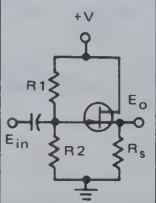
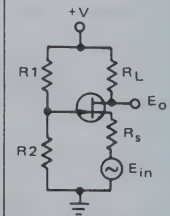


FIGURE 8 – AMPLIFIER EQUATIONS

Circuit Characteristic	Common Source	Source Follower	Common Gate
			
Voltage Gain	$A_v \approx \frac{-R_L}{\frac{1}{gm} + R_s}$	$A_v \approx \frac{R_s}{\frac{1}{gm} + R_s}$	$A_v \approx \frac{R_L}{\frac{1}{gm} + R_s}$
Input Impedance	$Z_{in} \approx R1 \parallel R2$	$Z_{in} \approx R1 \parallel R2$	$Z_{in} \approx R_s + \frac{1}{gm}$
Output Impedance	$Z_o \approx R_L$	$Z_o \approx R_s \parallel \frac{1}{gm}$	$Z_o \approx R_L$

2N5745 (SILICON)

For Specifications, See 2N4398, Volume I.

2N5758 (SILICON)
2N5759
2N5760

HIGH-VOLTAGE HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 100 Vdc (Min) — 2N5758
  = 120 Vdc (Min) — 2N5759
  = 140 Vdc (Min) — 2N5760
- DC Current Gain @ I_C = 3.0 Adc —
  h_{FE} = 25 (Min) — 2N5758
  = 20 (Min) — 2N5759
  = 15 (Min) — 2N5760
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 3.0 Adc
- Complement to PNP transistors 2N6226, 2N6227, 2N6228

6 AMPERE POWER TRANSISTORS NPN SILICON

100-120-140 VOLTS
150 WATTS



*MAXIMUM RATINGS

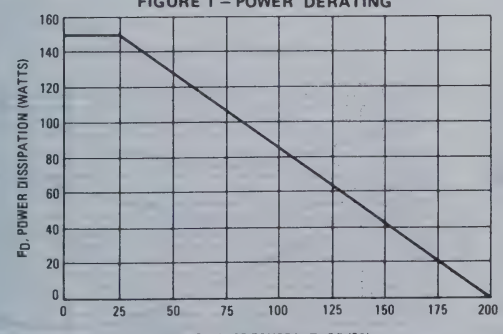
Rating	Symbol	2N5758	2N5759	2N5760	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	7.0			Vdc
Collector Current - Continuous Peak	I_C	6.0 10			Adc
Base Current	I_B	4.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.857			Watts W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

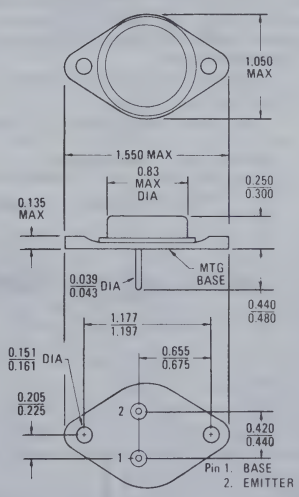
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 — POWER DERATING



Safe area limits are indicated by Figure 5.
Both limits are applicable and must be observed.



All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)**

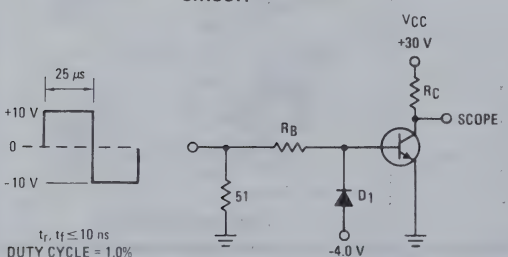
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0	2N5758		100	–	
	2N5759		120	–	
	2N5760		140	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N5758		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5759		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N5760		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)			–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N5758		25	100	
	2N5759		20	80	
	2N5760		15	60	
(I_C = 6.0 Adc, V_{CE} = 2.0 Vdc)	All Types		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)			–	1.0	
(I_C = 6.0 Adc, I_B = 1.2 Adc)			–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			–	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product		f_T			MHz
(I_C = 0.5 Adc, V_{CE} = 20 Vdc, f_{test} = 0.5 MHz)			1.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	300	
Small-Signal Current Gain		h_{fe}			–
(I_C = 2.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			15	–	

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

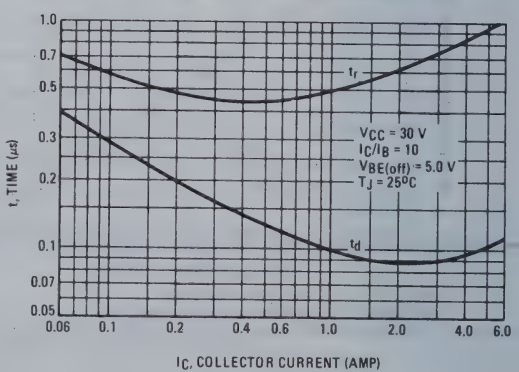


FIGURE 4 – THERMAL RESPONSE

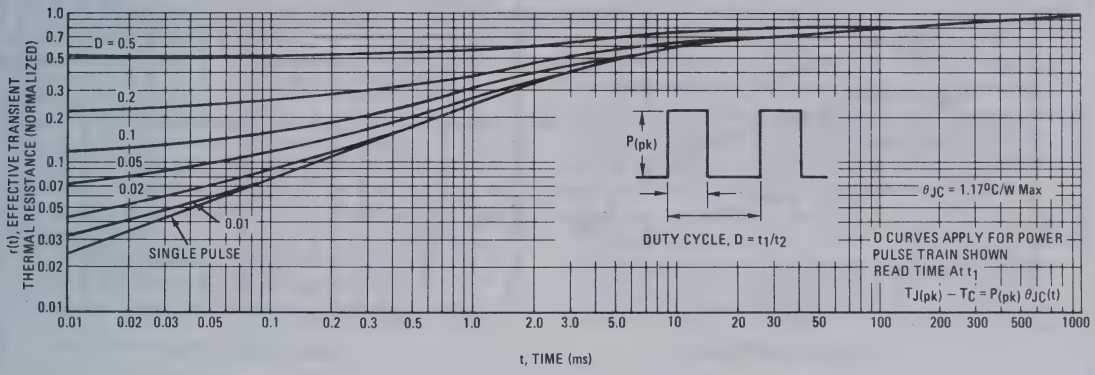
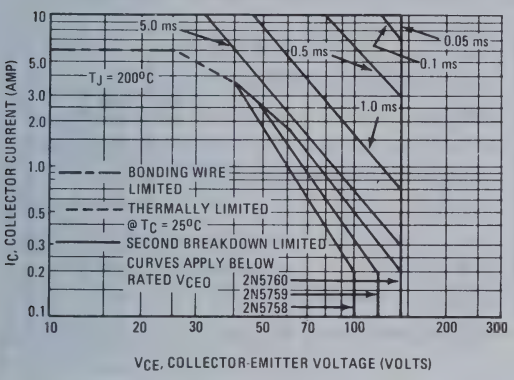


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

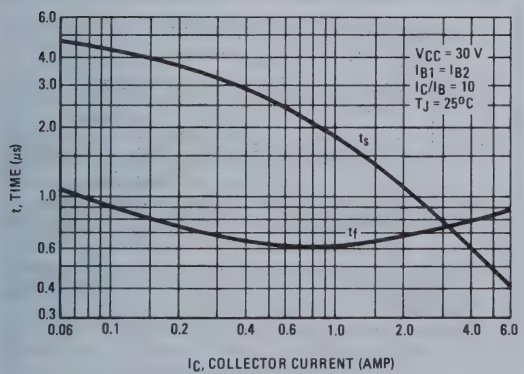


FIGURE 7 – CAPACITANCE

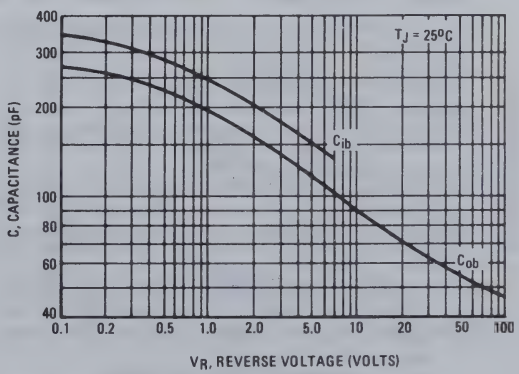


FIGURE 8 – DC CURRENT GAIN

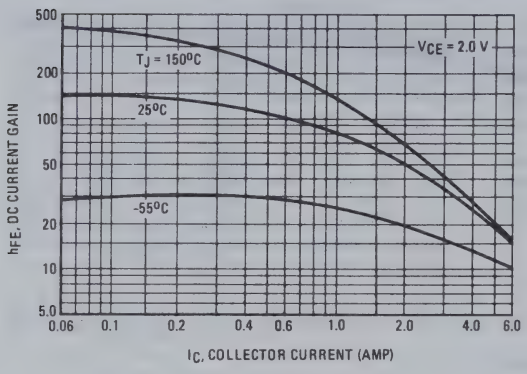


FIGURE 9 – COLLECTOR SATURATION REGION

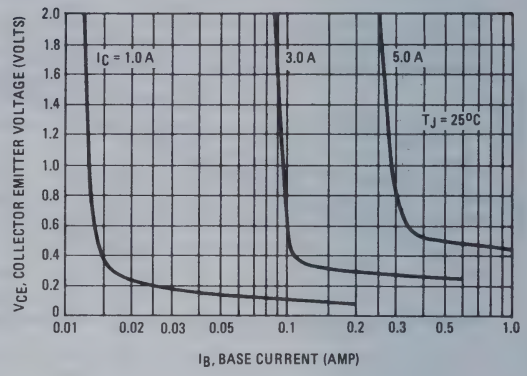


FIGURE 10 – "ON" VOLTAGE

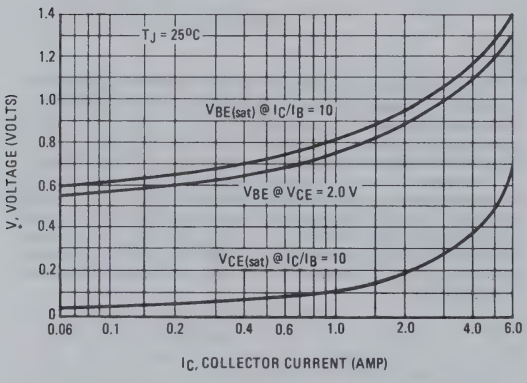


FIGURE 11 – TEMPERATURE COEFFICIENTS

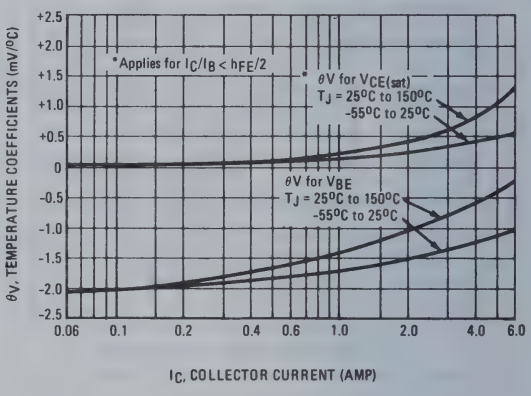


FIGURE 12 – COLLECTOR CUT OFF REGION

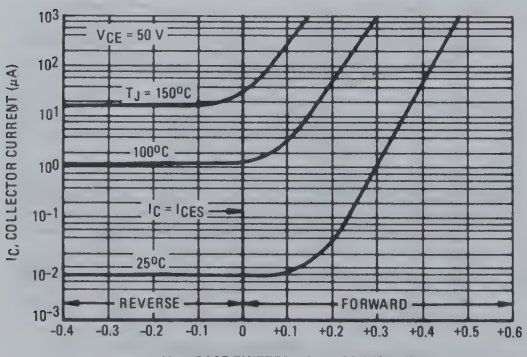
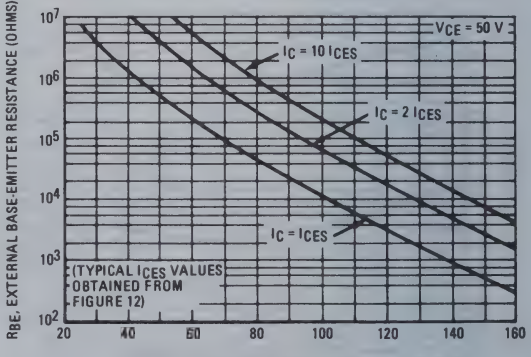


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5763 (SILICON)

High Reliability Products

Radiation Resistant

PNP SILICON ANNULAR TRANSISTOR

. . . designed for switching and amplifier applications. Unique internal package construction coupled with production lot-to-lot controls, insures device reliability and radiation resistance in ALL ⓣ types of radiation environments. Post irradiated electrical characteristics feature:

- High Collector-Emitter Breakdown Voltage – BV_{CEO} = 60 Vdc; BV_{CER} = 65 Vdc
- DC Current Gain Specified – 1.0 to 500 mAdc
- Similar to Type 2N2907A

PNP SILICON RADIATION RESISTANT TRANSISTOR



GUARANTEED RADIATION RESISTANCE CAPABILITIES

***AFTER 5×10^{14} n/cm² FAST NEUTRON (E ≥ 10 keV) EXPOSURE (Reactor Spectrum)**

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Emitter Breakdown Voltage	BV_{CER}			Vdc
(I_C = 10 mAdc, R_{BE} = 50 Ohms)		65	–	
(I_C = 10 mAdc, R_{BE} = 100 Ohms)		65	–	
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		7.0	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		14	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) ①		20	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) ①		15	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) ①		15	–	
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	25	nAdc
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	3.5	

***AFTER 1×10^7 RADS INTEGRATED GAMMA DOSE**

Characteristic	Symbol	Min	Max	Unit
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) ①		60	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) ①		30	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) ①		30	–	

TYPICAL RADIATION RESISTANT CAPABILITY

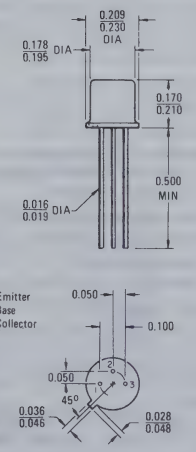
AT 1×10^9 RADS (Si)/Sec

Characteristic	Symbol	Typ	Unit
Prompt Photocurrent (Transient Gamma Pulse Width (t_γ)>500 ns)	i_{pp}	< 20	mAdc

*Indicates JEDEC Registered Data

① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

ⓣ Contact the Transistor Radiation Department for Additional Information on Classified Effects/Capabilities.



Collector Connected to Case
CASE 22(1)
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.28	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.8 10.3	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

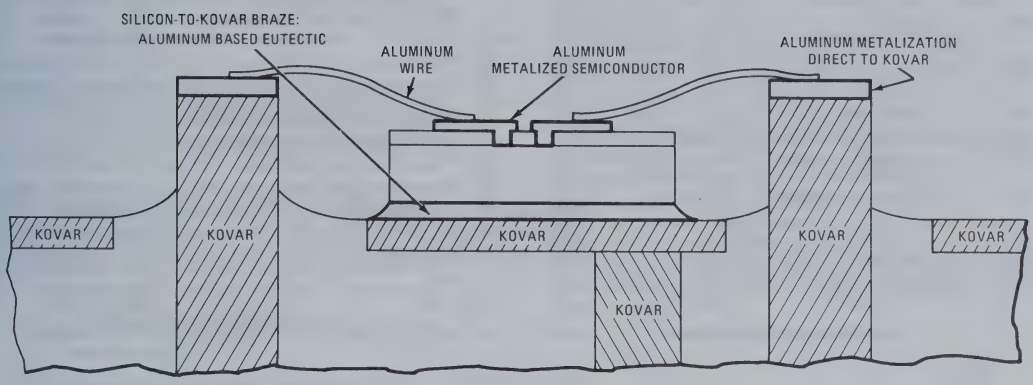
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ① (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 50 ohms) (I_C = 10 mAdc, R_{BE} = 100 ohms)	BV_{CER}	 65 65	 – –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	65	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (Figure 3) (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) ① (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) ① (I_C = 500 mAdc, V_{CE} = 10 Vdc) ①	h_{FE}	 70 70 70 35 35	 – – – –	–
Collector-Emitter Saturation Voltage ① (See Figure 2) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	 – –	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage ① (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	 – –	 1.3 2.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product ② (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	8.0	pF
Emitter-Base Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	30	pF
SWITCHING CHARACTERISTICS				
Delay Time	(V_{CC} = 6.0 Vdc, $I_{C(on)}$ = 150 mAdc, I_{B1} = 15 mAdc) (Figure 6)	t_d	–	10	ns
Rise Time		t_r	–	40	ns
Storage Time	(V_{CC} = 6.0 Vdc, $I_{C(on)}$ = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 7)	t_s	–	200	ns
Fall Time		t_f	–	50	ns

*Indicates JEDEC Registered Data.

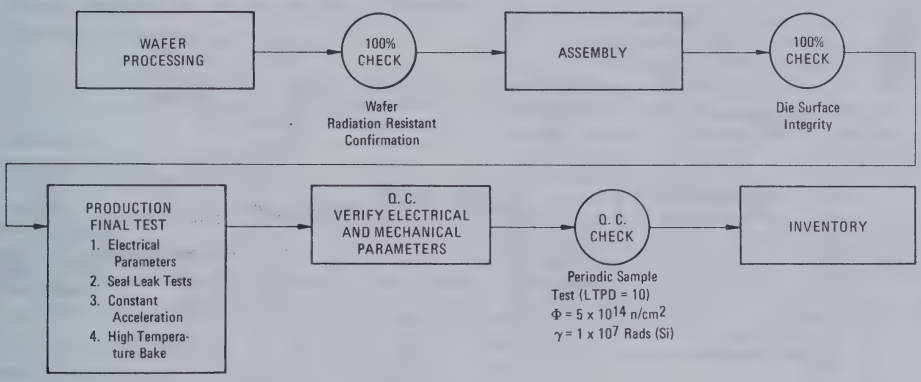
① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

② f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

INTERNAL CONSTRUCTION



RADIATION RESISTANT LOT-TO-LOT ASSURANCE



NOTE: If desired, alternate High Reliability Processing is available to meet customer specific processing requirements.

EFFECTS OF FAST NEUTRON DOSAGE

FIGURE 1 – MINIMUM DC CURRENT GAIN

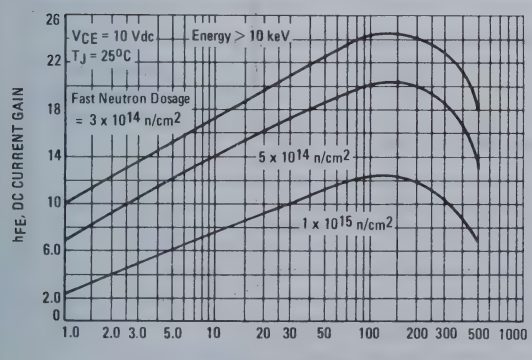


FIGURE 2 – MAXIMUM COLLECTOR-EMITTER SATURATION VOLTAGE

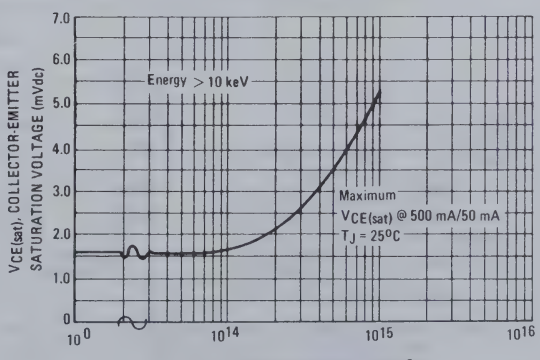


FIGURE 3 – MAXIMUM COLLECTOR-BASE LEAKAGE CURRENT

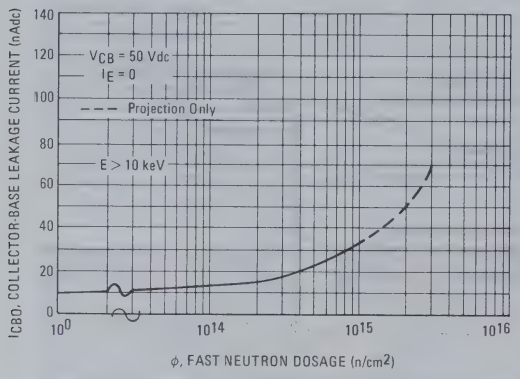


FIGURE 4 – TYPICAL PROMPT PHOTOCURRENT GENERATION

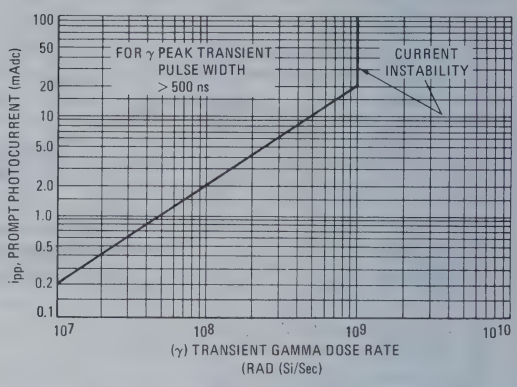


FIGURE 5 – MINIMUM DC CURRENT GAIN AFTER 1 x 10^7 RAD (Si)

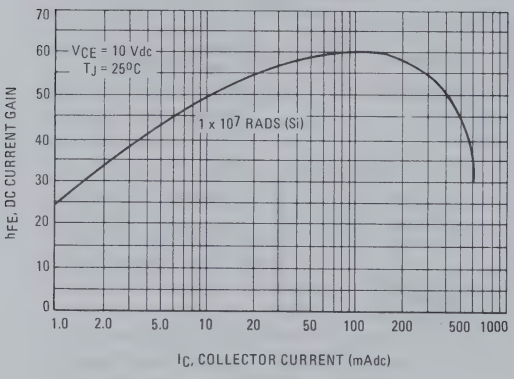


FIGURE 6 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

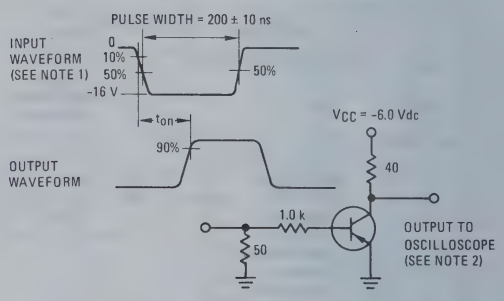
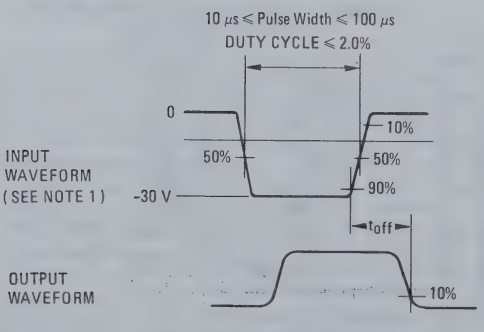
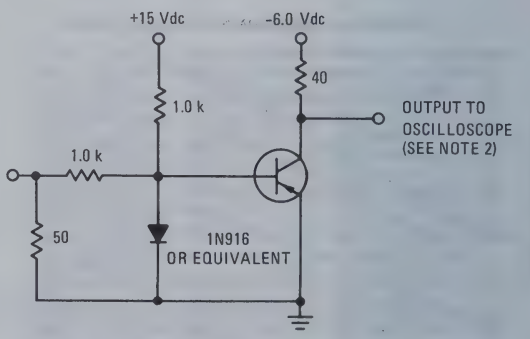


FIGURE 7 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT





Note 1: The rise time (t_r) of the applied pulse shall be ≤ 2.0 ns, Duty Cycle ≤ 2.0%, and the generator source impedance shall be 50 Ohms.

Note 2: Oscilloscope: R_{in} ≥10 k Ohms, C_{in} ≤12 pF, Rise Time ≤5.0 ns.

2N5777 thru 2N5780 (SILICON)
MRD14B

PLASTIC NPN SILICON PHOTO DARLINGTON AMPLIFIERS

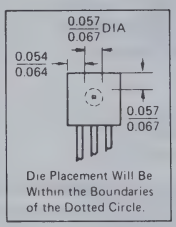
. . . designed for applications in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring extremely high radiation sensitivity, and stable characteristics.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Range of Radiation Sensitivities and Voltages for Design Flexibility
- TO-92 Clear Plastic Package for Standard Mounting
- Annular Passivated Structure for Stability and Reliability
- Precision Die Placement

12, 25, 40 VOLT PHOTO DARLINGTON AMPLIFIERS NPN SILICON

200 MILLIWATTS





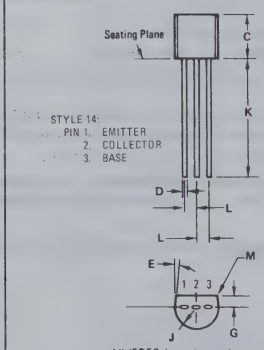
Die Placement Will Be Within the Boundaries of the Dotted Circle.

MAXIMUM RATINGS

Rating	Symbol	MRD14B	2N5777* 2N5779	2N5778* 2N5780	Unit
Collector-Emitter Voltage	V_{CEO}	12	25	40	Volts
Collector-Base Voltage	V_{CBO}	18	25	40	Volts
Emitter-Base Voltage	V_{EBO}	8.0	8.0	12	Volts
Light Current	I_L	← 250 →			mA
Total Device Dissipation @ $T_A = 25^oC$	P_D	← 200 →			mW
Derate above 25^oC		← 2.67 →			$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-65 to +100			^oC

*Indicates JEDEC Registered Data.

(1) Heat Sink should be applied to leads during soldering to prevent case temperature from exceeding 100^oC.

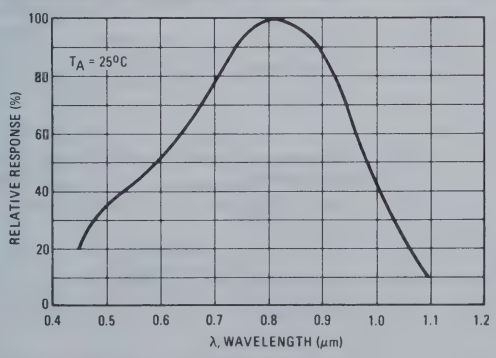


All JEDEC dimensions and notes apply

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
C	0.175	0.185	4.45	4.70
D	0.016	0.019	0.407	0.482
E	5° NOM		5° NOM	
G	0.045	0.055	1.15	1.39
J	0.085	0.095	2.16	2.42
K	0.500		12.70	
L	0.050 TP		1.27 TP	
M	0.003	0.013	0.076	0.330

CASE 29-01
TO-92
PLASTIC

FIGURE 1 – CONSTANT ENERGY SPECTRAL RESPONSE



* STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector Dark Current (Note 2) (V_{CE} = 12 V)		I_{CEO}	–	–	0.1	μA
Collector-Emitter Breakdown Voltage (Note 2) (I_C = 10 mA)		BV_{CEO}				Volts
	MRD14B		12	–	–	
	2N5777, 2N5779		25	–	–	
	2N5778, 2N5780		40	–	–	
Collector-Base Breakdown Voltage (Note 2) (I_C = 100 μA)		BV_{CBO}				Volts
	MRD14B		18	–	–	
	2N5777, 2N5779		25	–	–	
	2N5778, 2N5780		40	–	–	
Emitter-Base Breakdown Voltage (Note 2) (I_E = 100 μA)		BV_{EBO}				Volts
	MRD14B		8.0	–	–	
	2N5777, 2N5779		8.0	–	–	
	2N5778, 2N5780		12	–	–	

* OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Collector Light Current (Notes 1,4,5) (V_{CE} = 5.0 V)		–	I_L				mA
	MRD14B			0.5	2.0	–	
	2N5777, 2N5778			0.5	4.0	–	
	2N5779, 2N5780			2.0	8.0	–	
DC Current Gain (Note 2) (V_{CE} = 5.0 V, I_C = 0.5 mA)		–	h_{FE}				–
	2N5777, 2N5778			2.5 k	–	–	
	2N5779, 2N5780			5.0 k	–	–	
Wave Length of Maximum Sensitivity		1	λ_s	0.7	0.8	1.0	μm
Turn-On Delay Time (Notes 3, 4)		2,3	t_{d1}	–	–	100	μs
Rise Time (Notes 3, 4)		2,3	t_r	–	–	250	μs
Turn-Off Delay Time (Notes 3, 4)		2,3	t_{d2}	–	–	5.0	μs
Fall Time (Notes 3, 4)		2,3	t_f	–	–	150	μs
Collector-Base Capacitance (V_{CB} = 10 V, f = 1.0 MHz, I_E = 0)	2N5777 thru 2N5780	–	C_{cb}	–	–	10	pF

*Indicates JEDEC Registered Data.

NOTES:

1. Radiation Flux Density (H) equal to 2.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ ≈ 0.9 μm) with a pulse width equal to or greater than 500 microseconds (see Figures 2 and 3).
4. Measurement mode with no electrical connection to the base lead.
5. Die faces curved side of package.

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

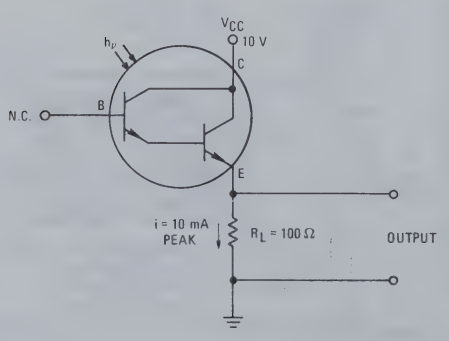
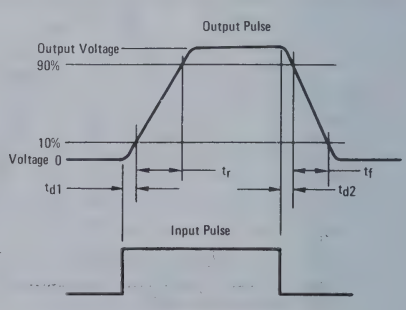


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



2N5793 (SILICON)
2N5794

DUAL NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry to the PNP 2N5795 and 2N5796.

- DC Current Gain Specified – 0.1 mAdc to 300 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc
- All Leads Electrically Isolated for Design Flexibility
- Each Transistor Similar to 2N2218A or 2N2219A

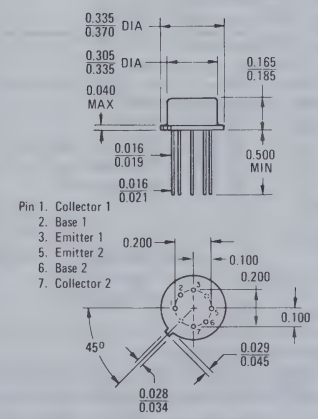
NPN SILICON DUAL TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	75		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		Each Device	Total Package	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C

*Indicates JEDEC Registered Data.



PINS 4 AND 8 OMITTED
All Leads Electrically Isolated from Case

CASE 654-07

2N5793, 2N5794 (continued)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	75	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	10	nAdc
Collector 1 to Collector 2 Leakage Current ($V_{1C\text{-}2C}$ = ±50 Vdc)		$I_{1C\text{-}2C}$	–	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N5793		20	–	
	2N5794		35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N5793		25	–	
	2N5794		50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		35	–	
	2N5794		75	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N5793		20	–	
	2N5794		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		40	120	
	2N5794		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		25	–	
	2N5794		40	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	0.9	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	250	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	8.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	–	25	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (See Figure 1)	t_d	–	15	ns
Rise Time		t_r	–	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (See Figure 2)	t_s	–	250	ns
Fall Time		t_f	–	60	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – TURN-ON TIME TEST

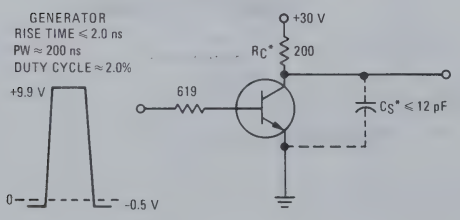
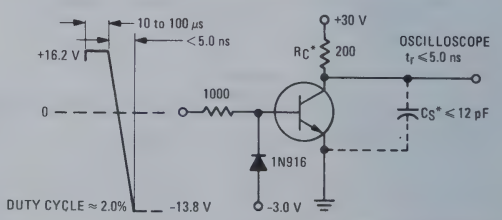


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

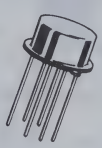
2N5795 (SILICON)
2N5796

DUAL PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuits with the NPN 2N5793 and 2N5794.

- DC Current Gain Specified — 0.1 mAdc to 500 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- All Leads Electrically Isolated for Design Flexibility
- Each Transistor Similar to 2N2904A or 2N2905A

PNP SILICON DUAL TRANSISTORS

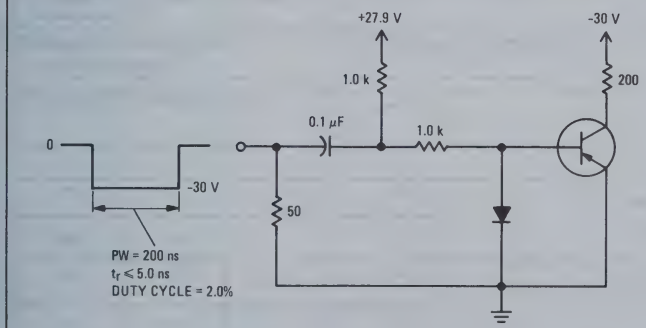


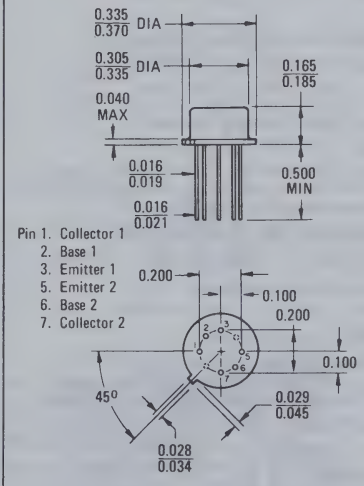
***MAXIMUM RATINGS**

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C
		Each Device	Total Package	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C

*Indicates JEDEC Registered Data.

FIGURE 1 — SATURATED SWITCHING TIMES TEST CIRCUIT





(Pins 4 and 8 Omitted)
All Leads Electrically Isolated from Case

CASE 654-07

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	20	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
Collector 1 to Collector 2 Leakage Current (V_{1C-2C} = ±50 Vdc)		I_{1C-2C}	–	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N5795		40	–	
	2N5796		75	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N5795		40	–	
	2N5796		100	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N5795		40	–	
	2N5796		100	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N5795		20	–	
	2N5796		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N5795		40	120	
	2N5796		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N5795		40	–	
	2N5796		50	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.6	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	8.0	pF
Emitter-Base Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	–	30	pF
SWITCHING CHARACTERISTICS (See Figure 1)					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	–	12	ns
Rise Time		t_r	–	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	–	100	ns
Fall Time		t_f	–	40	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N5797 (SILICON) thru 2N5800

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Symmetrical depletion mode Junction Field-Effect Transistors designed primarily for low-power, audio amplifier applications.

- Low Reverse Transfer Capacitance — C_{rss} = 1.0 pF (Max)
- Drain and Source Interchangeable
- Low Gate Reverse Current — I_{GSS} = 1.0 nAdc (Max)
- Unibloc Plastic Package Encapsulation

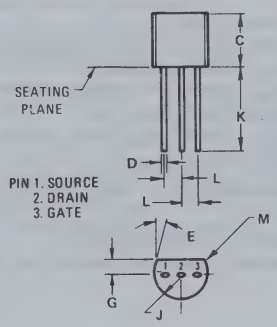
P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^{o}C

*Indicates JEDEC Registered Data.



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	5^o NOM		5^o NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330

CASE 29-01
TO-92

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTIC					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -15 Vdc, I_D = -10 μAdc)	2N5797	$V_{GS(off)}$	0.5	4.0	Vdc
	2N5798		0.8	6.0	
	2N5799		1.2	8.0	
	2N5800		2.0	9.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	–	1.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
ON CHARACTERISTICS					
Zero Gate Voltage Drain Current (V_{DS} = -15 Vdc, V_{GS} = 0)	2N5797	I_{DSS}	0.02	0.1	mAdc
	2N5798		0.08	0.4	
	2N5799		0.25	1.0	
	2N5800		0.70	2.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (1) (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5797	$\lvert y_{fs} \rvert$	60	225	mmhos
	2N5798		100	400	
	2N5799		160	500	
	2N5800		250	700	
Output Admittance (1) (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5797	$\lvert y_{os} \rvert$	–	1.0	μmhos
	2N5798		–	2.5	
	2N5799		–	5.0	
	2N5800		–	10	
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	5.0	pF
Reverse Transfer Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.0	pF
Common-Source Noise Figure (V_{DS} = -15 Vdc, V_{GS} = 0, R_S = 1.0 Megohm, f = 1.0 kHz, BW = 1.0 Hz)		NF	–	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)		e_n	–	110	$nV/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 360 ms, Duty Cycle = 2.0%.

TYPICAL SMALL-SIGNAL CHARACTERISTICS

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

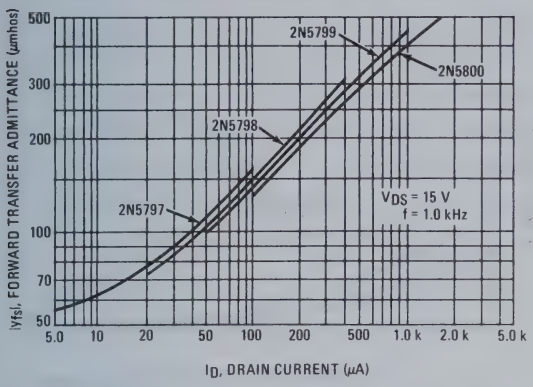
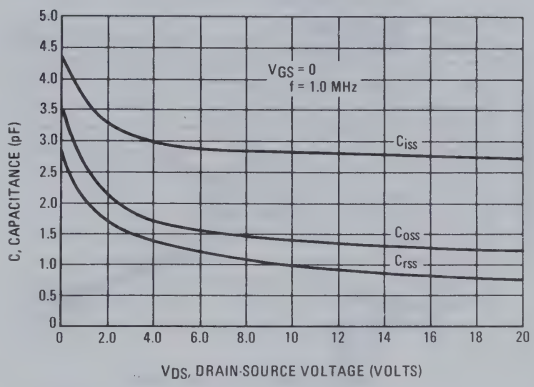


FIGURE 2 – CAPACITANCE



TYPICAL NOISE FIGURE

FIGURE 3 – EFFECTS OF FREQUENCY

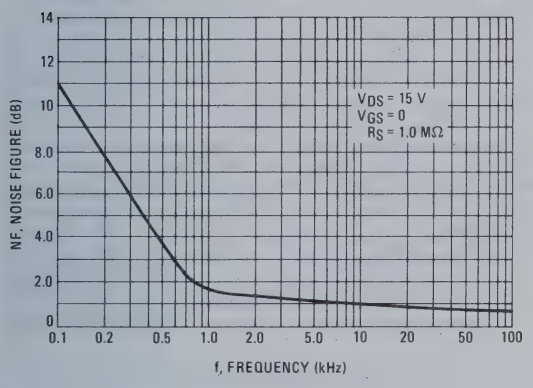


FIGURE 4 – EFFECTS OF SOURCE RESISTANCE

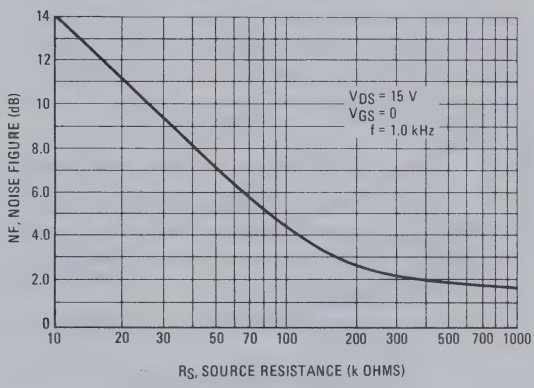
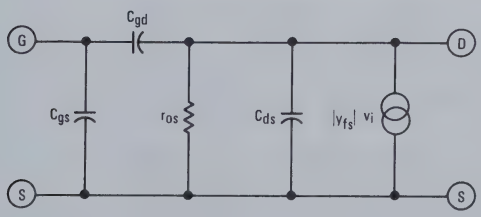


FIGURE 5 – LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}$

TYPICAL LIMIT TRANSFER CHARACTERISTICS
(TEMPERATURES NOTED ARE T_J)

FIGURE 6 – 2N5797

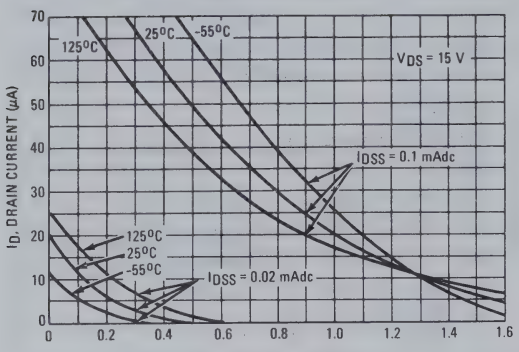


FIGURE 7 – 2N5798

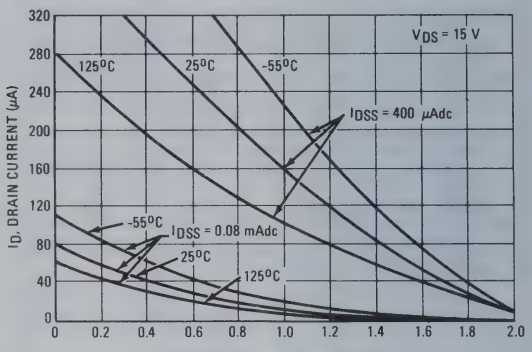


FIGURE 8 – 2N5799

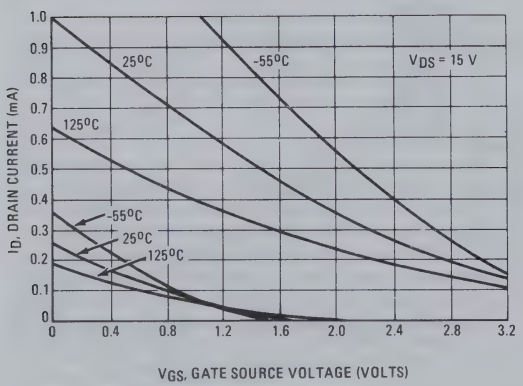
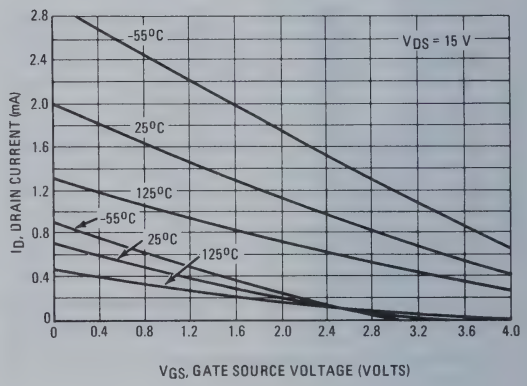


FIGURE 9 – 2N5800



2N5829 (SILICON)

PNP SILICON SMALL-SIGNAL RF TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator, and mixer applications.

- Low Noise Figure – NF = 2.5 dB (Max) @ f = 450 MHz
- High Power Gain – G_{pe} = 17 dB (Min) @ f = 450 MHz
- High Gain-Bandwidth Product – f_T = 1600 MHz (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.4 pF (Typ)

PNP SILICON RF AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

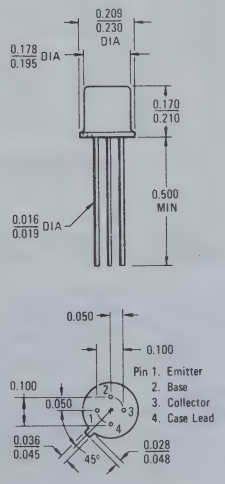
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	40	150	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1200	1600	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	2 0	–	200	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_C$	1.0	–	8.0	ps
Noise Figure (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	NF	–	2.3	2.5	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	17	–	–	dB

*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 20 (10)
TO-72 PACKAGE

ACTIVE ELEMENTS ISOLATED FROM CASE

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

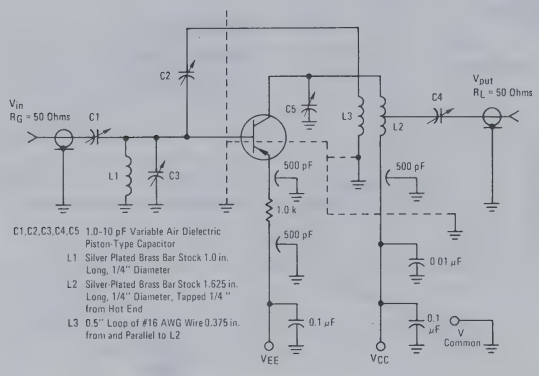


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

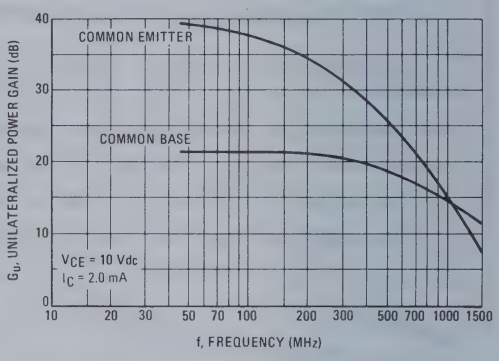


FIGURE 3 – NOISE FIGURE versus FREQUENCY

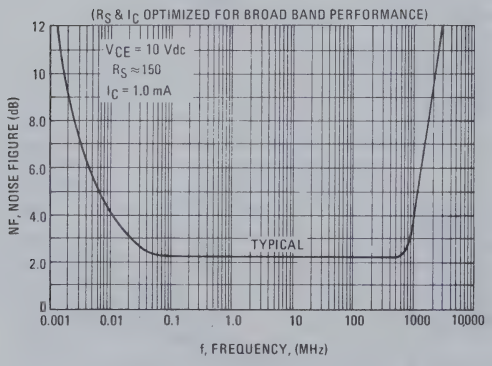


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

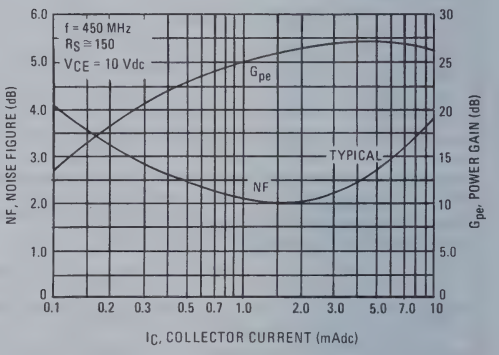


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

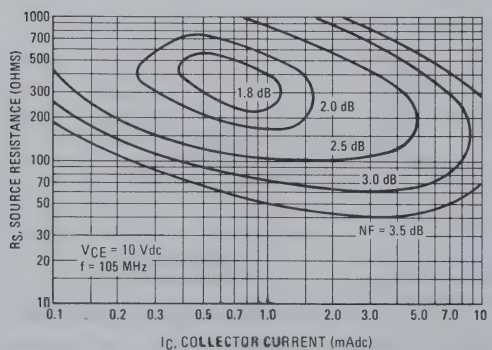
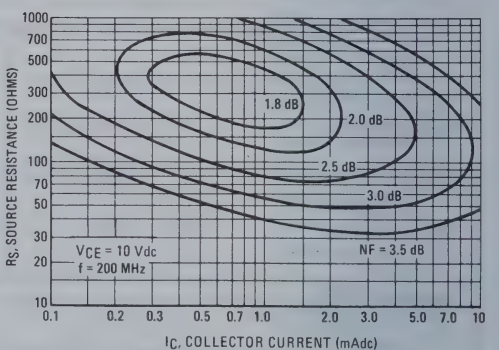


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

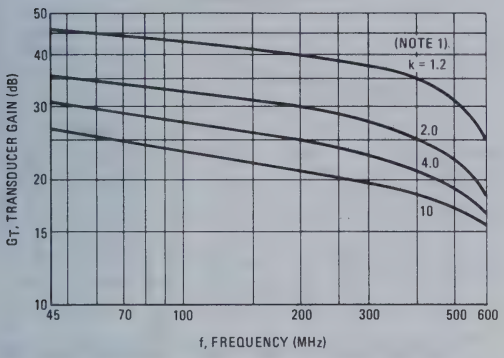


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

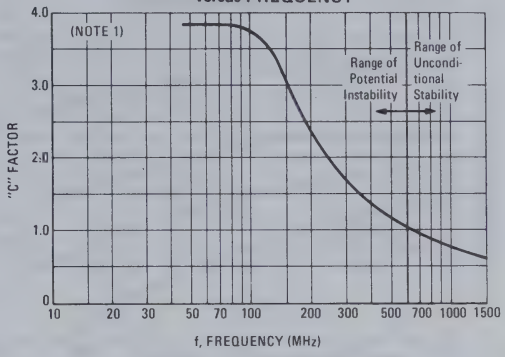


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

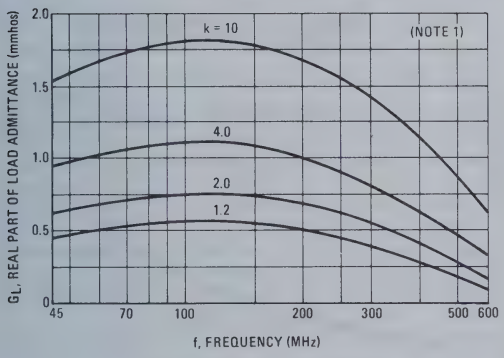


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

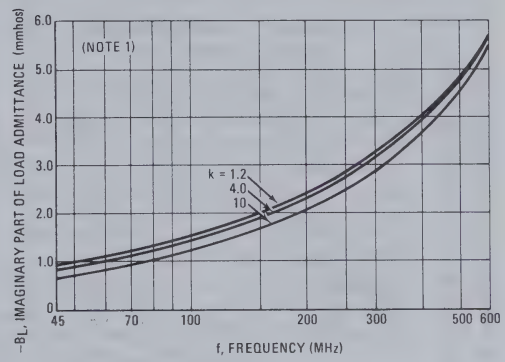


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

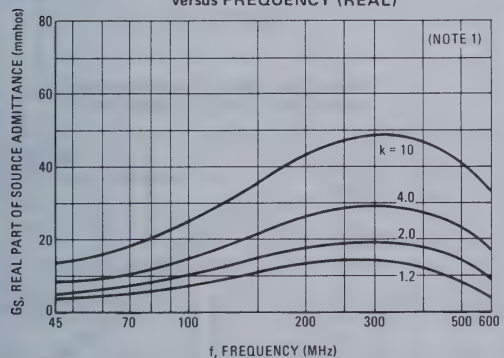
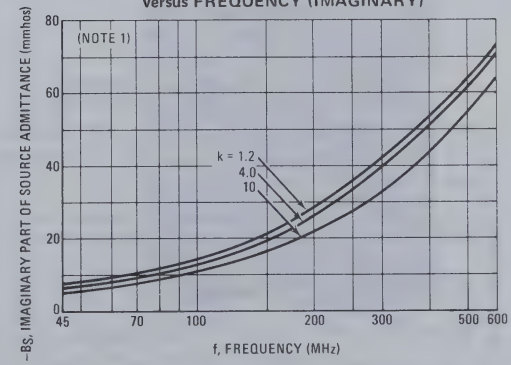


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

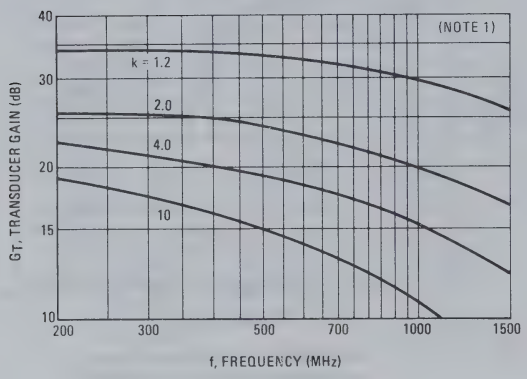


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

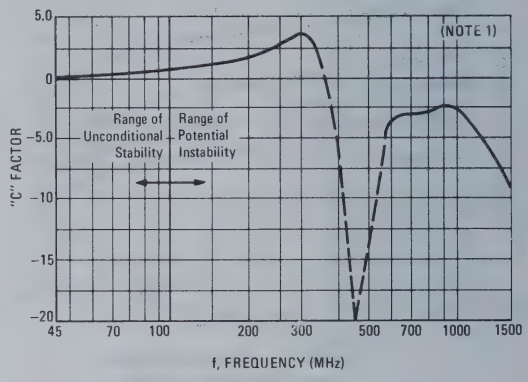


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

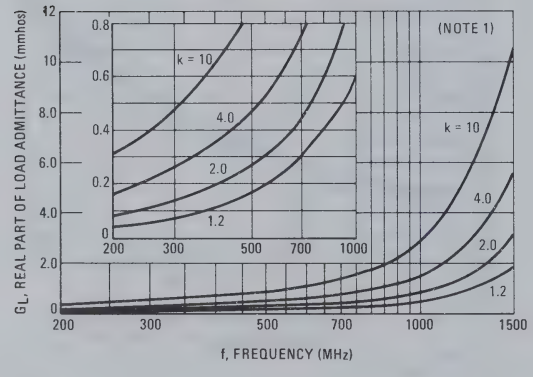


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

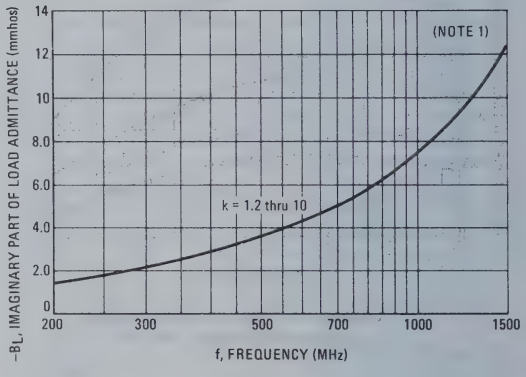


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

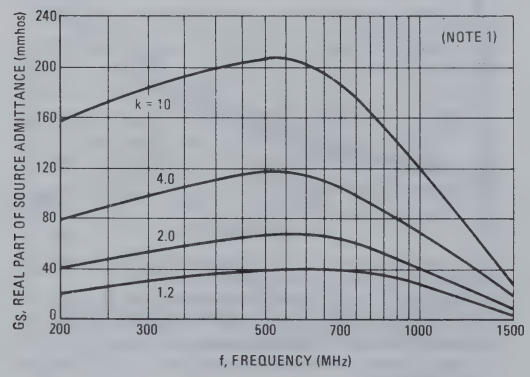


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

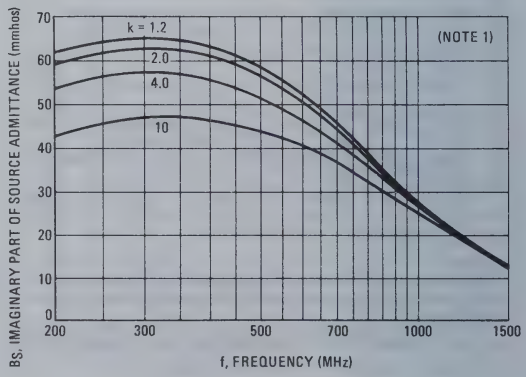


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

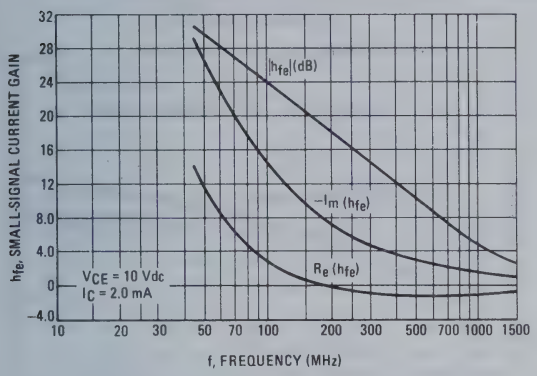


FIGURE 20 – POLAR h_{fe}

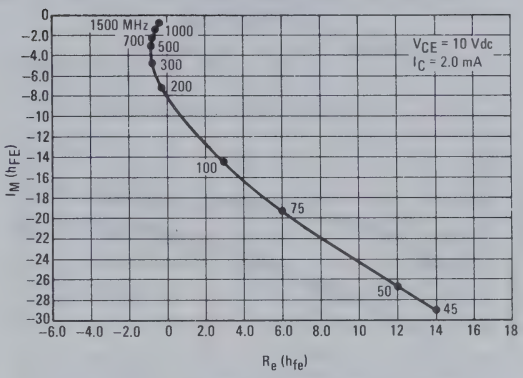


FIGURE 21 – f_T versus COLLECTOR CURRENT

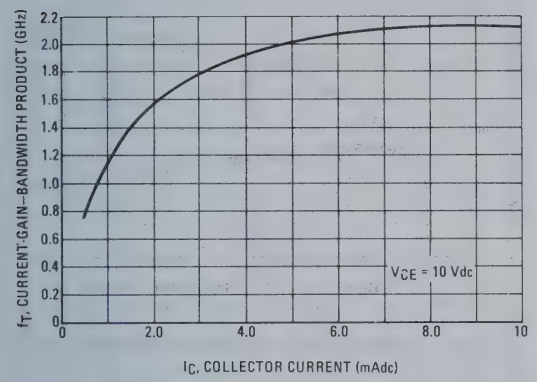


FIGURE 22 – DC CURRENT GAIN

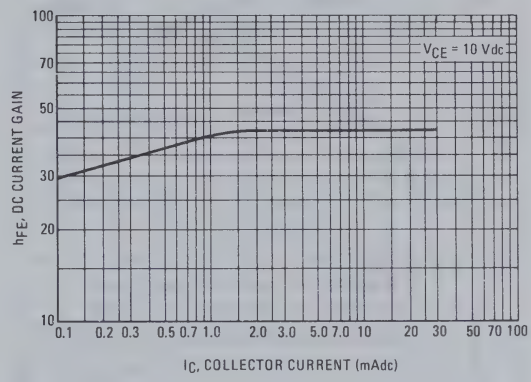


FIGURE 23 – CAPACITANCE

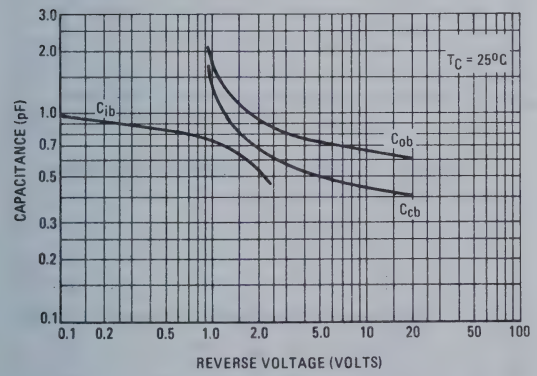
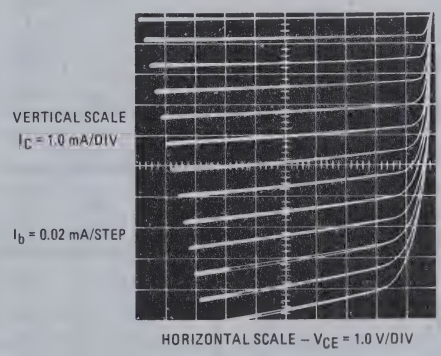


FIGURE 24 – COLLECTOR CHARACTERISTICS

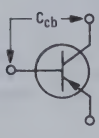




Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

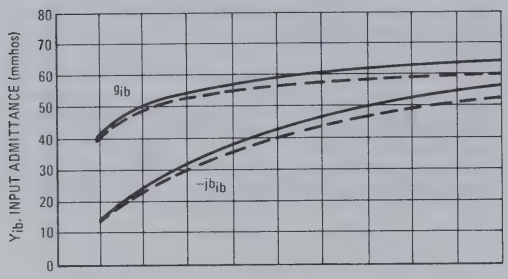


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

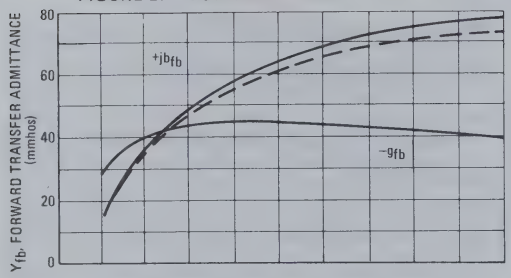


FIGURE 29 – OUTPUT ADMITTANCE

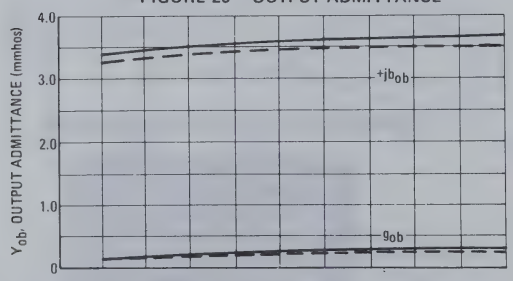
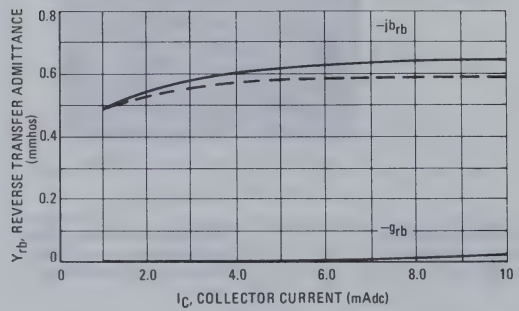


FIGURE 31 – REVERSE TRANSFER ADMITTANCE



COMMON EMITTER

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 26 – INPUT ADMITTANCE

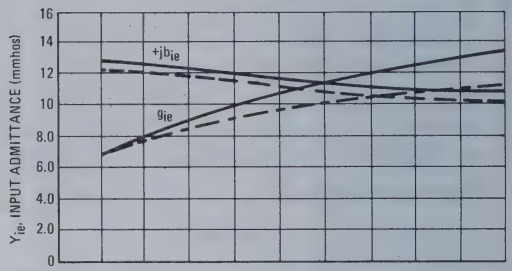


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

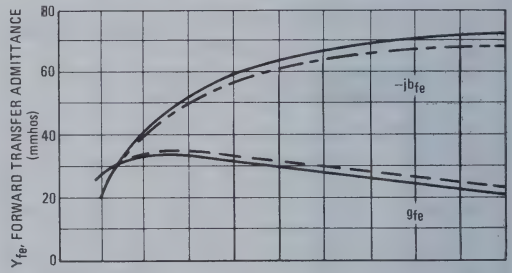


FIGURE 30 – OUTPUT ADMITTANCE

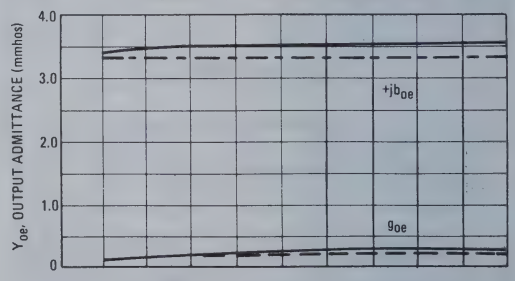
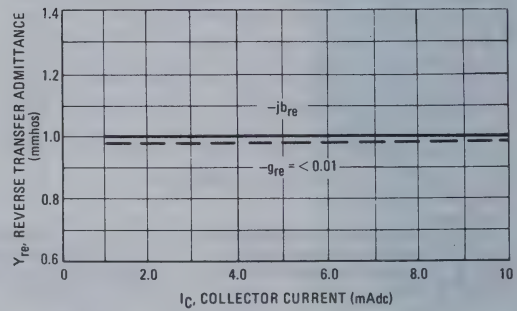


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

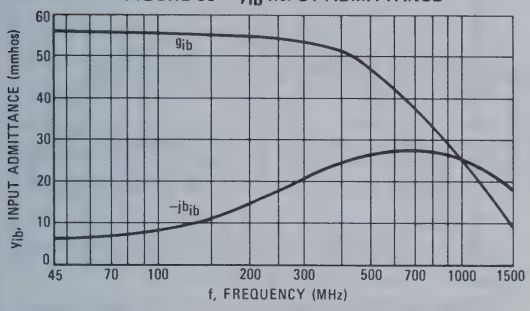


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

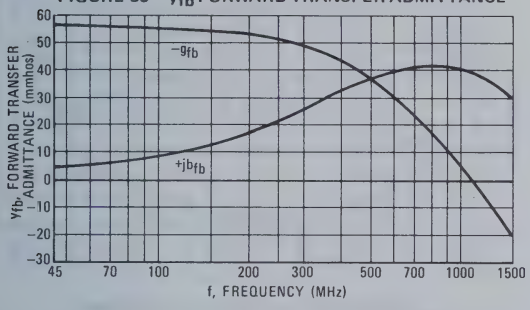


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

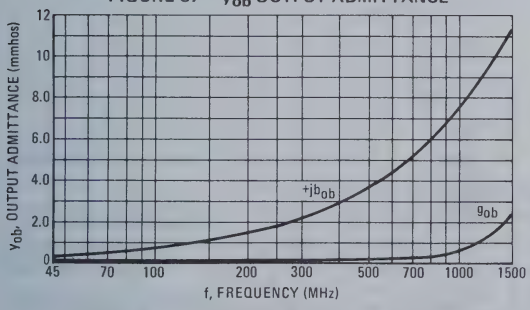
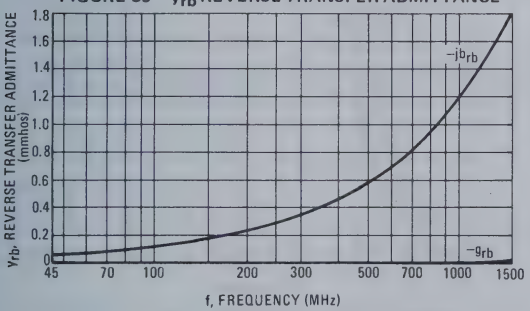


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

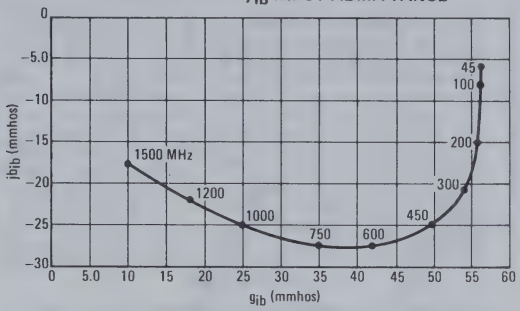


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

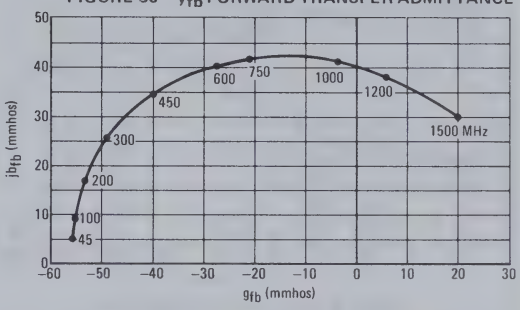


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

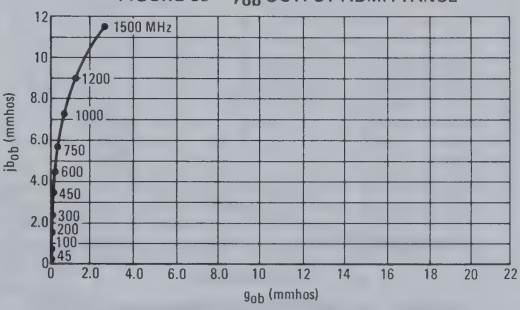
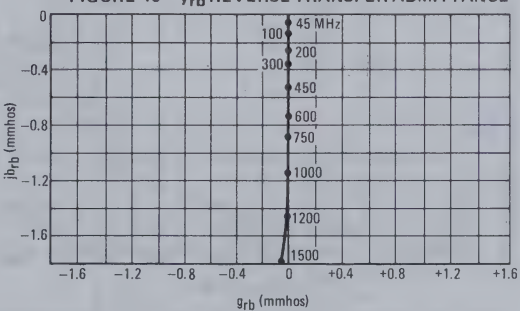


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER Y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

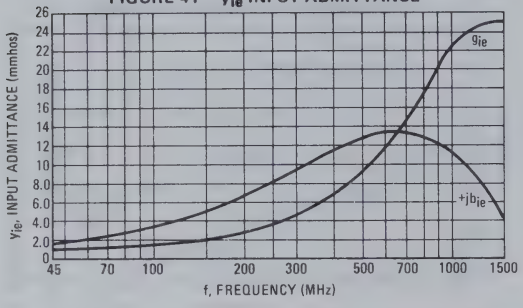


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

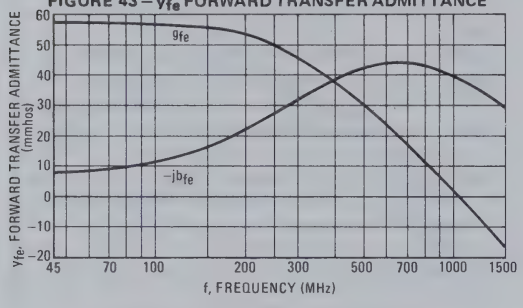


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

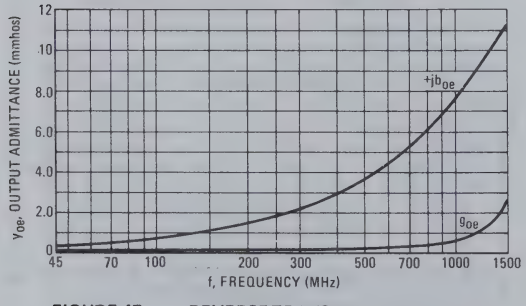
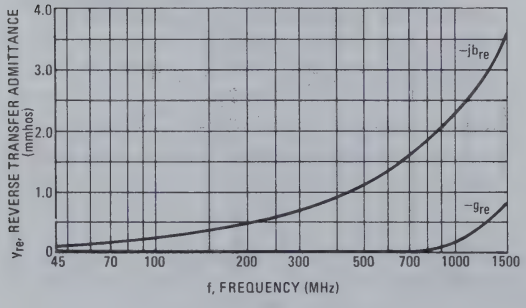


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

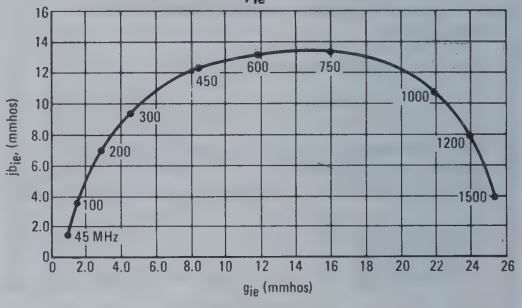


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

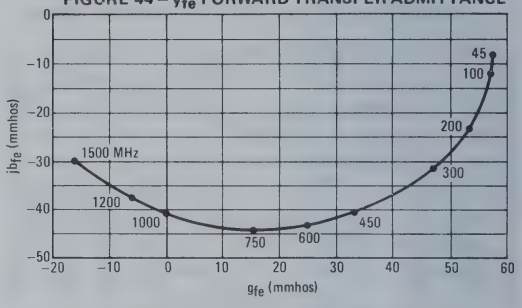


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

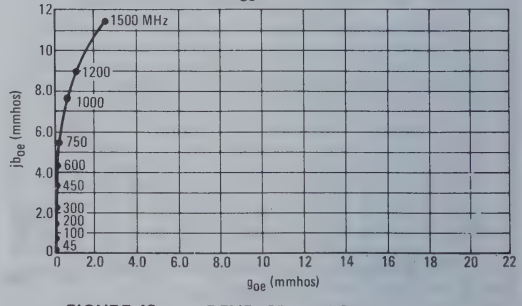
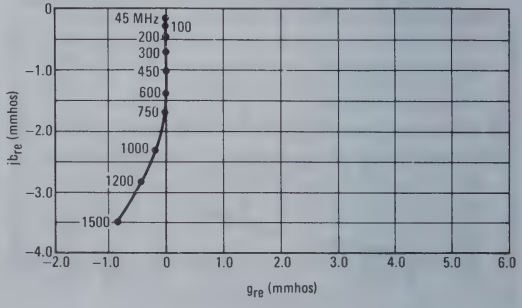


FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



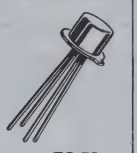
2N5835 (SILICON)
2N5836
2N5837

NPN SILICON HIGH-FREQUENCY TRANSISTORS

. . . designed primarily for use in fast current-mode switching circuits in military and industrial equipment. Suitable for use in general high-frequency amplifier applications to 1.5 GHz.

- High Current-Gain–Bandwidth Product –
  f_T = 2.5 GHz (Min) @ I_C = 10 mAdc – 2N5835
  2.0 GHz (Min) @ I_C = 50 mAdc – 2N5836
  1.7 GHz (Min) @ I_C = 100 mAdc – 2N5837
- Fast Non-Saturated Switching Times –
  t_r = 250 ps (Typ) @ I_C = 10 mAdc – 2N5835
  320 ps (Typ) @ I_C = 50 mAdc – 2N5836
  650 ps (Typ) @ I_C = 100 mAdc – 2N5837
- Characterized with Scattering Parameters

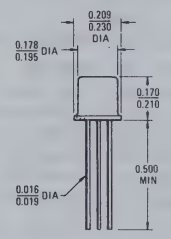
NPN SILICON HIGH-FREQUENCY TRANSISTORS

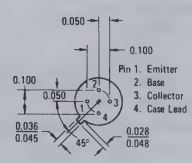


TO-72
2N5835



TO-46
2N5836
2N5837



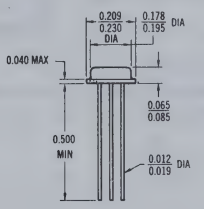


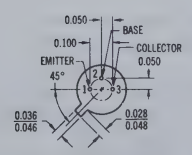
CASE 20 (10)
TO-72

*MAXIMUM RATINGS

Rating	Symbol	2N5835	2N5836	2N5837	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	5.0	Vdc
Collector-Base Voltage	V_{CB}	15	15	10	Vdc
Emitter-Base Voltage	V_{EB}	3.5	3.5	3.5	Vdc
Collector Current — Continuous	I_C	15	200	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	— —	— —	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	— —	2.0 6.67	2.0 6.67	Watts mW/°C
Storage Junction Temperature Range	T_{stg}	← -65 to +200 →			°C

*Indicates JEDEC Registered Data.





CASE 26
TO-46 PACKAGE

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

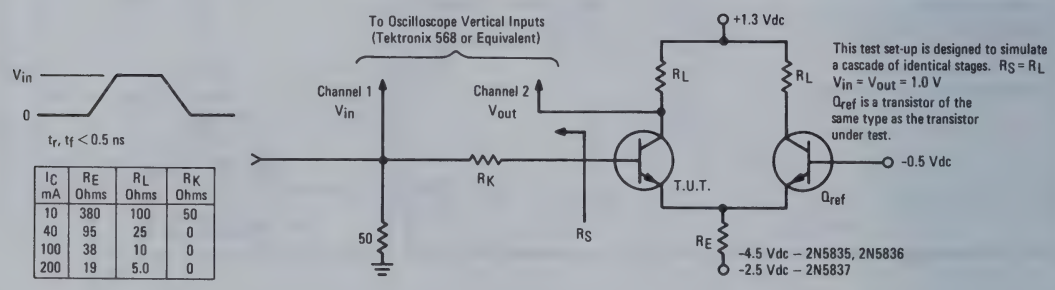
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	2N5835		15	–	–	
(I_C = 100 μAdc, I_E = 0)	2N5836		15	–	–	
	2N5837		10	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}	3.5	–	–	Vdc
(I_E = 100 μAdc, I_C = 0)						
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 7.5 Vdc, I_E = 0)	2N5835		–	–	0.01	
(V_{CB} = 10 Vdc, I_E = 0)	2N5836		–	–	10	
(V_{CB} = 5.0 Vdc, I_E = 0)	2N5837		–	–	10	
Emitter Cutoff Current		I_{EBO}	–	–	100	μAdc
(V_{EB} = 3.0 Vdc, I_C = 0)						
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc)	2N5835		25	–	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc)	2N5836		25	–	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	2N5837		25	–	–	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc)	2N5835		–	–	0.9	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc)	2N5836		–	–	0.9	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	2N5837		–	–	0.9	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product ①		f_T				GHz
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	2N5835		2.5	–	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	2N5836		2.0	–	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 200 MHz)	2N5837		1.7	–	–	
Collector-Base Capacitance		C_{cb}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5835		–	–	0.8	
	2N5836		–	–	3.5	
(V_{CB} = 5.0 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5837		–	–	5.0	
Collector-Base Time Constant ②		$r_b'C_c$				ps
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz)	2N5835		–	5.0	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz)	2N5836		–	6.0	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 63.6 MHz)	2N5837		–	6.0	–	
SWITCHING CHARACTERISTICS ②						
Rise Time (See Figure 1) (I_C = 10 mAdc)	2N5835	t_r	–	250	–	ps
(I_C = 40 mAdc)	2N5836		–	320	–	
(I_C = 100 mAdc)	2N5837		–	650	–	

*Indicates JEDEC Registered Data

① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

② Typical values shown in addition to JEDEC Registered Data.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



IC mA	RE Ohms	RL Ohms	RK Ohms
10	380	100	50
40	95	25	0
100	38	10	0
200	19	5.0	0

FIGURE 2 – SWITCHING TIME

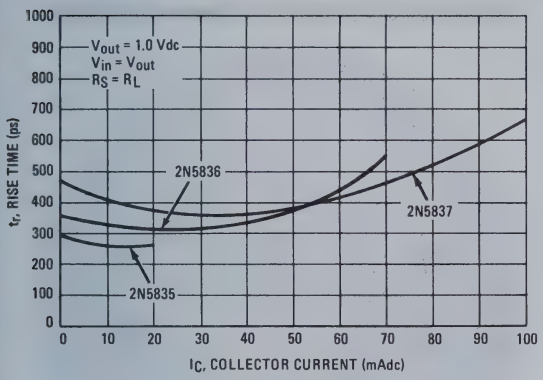


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

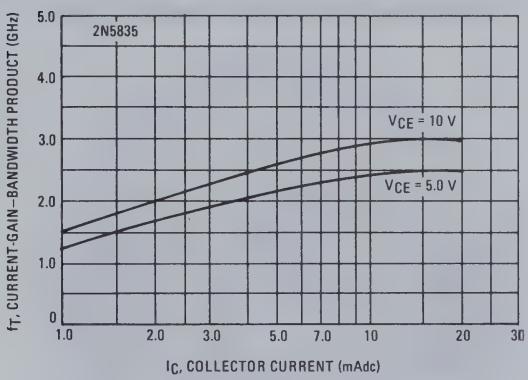


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

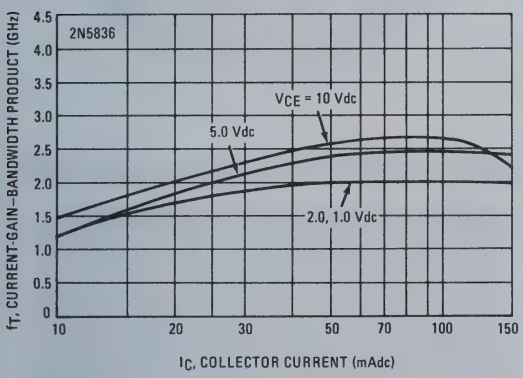


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

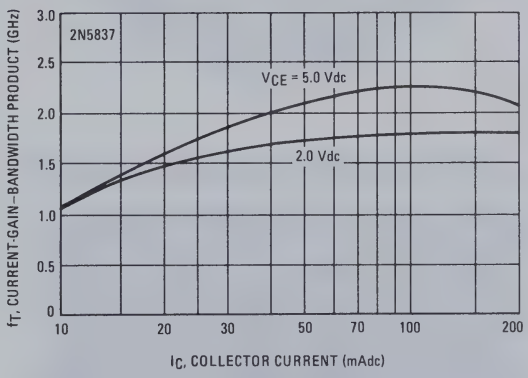


FIGURE 6 – COLLECTOR-BASE TIME CONSTANT

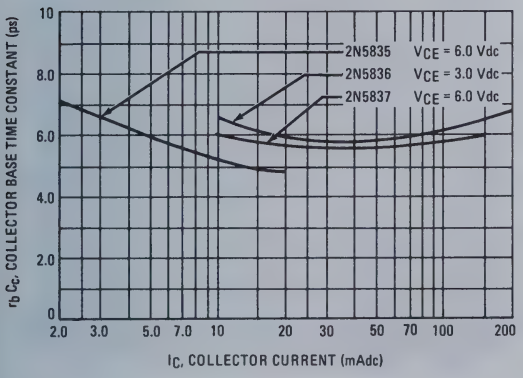
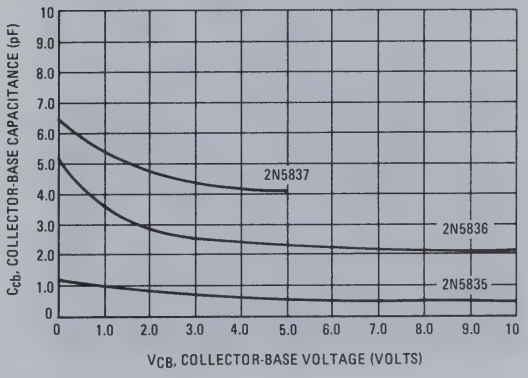


FIGURE 7 – COLLECTOR-BASE CAPACITANCE



2N5835 SCATTERING PARAMETERS
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, $Z_G = Z_L$ = 50 Ohms)

FIGURE 8 – S_{11}, INPUT REFLECTION COEFFICIENT

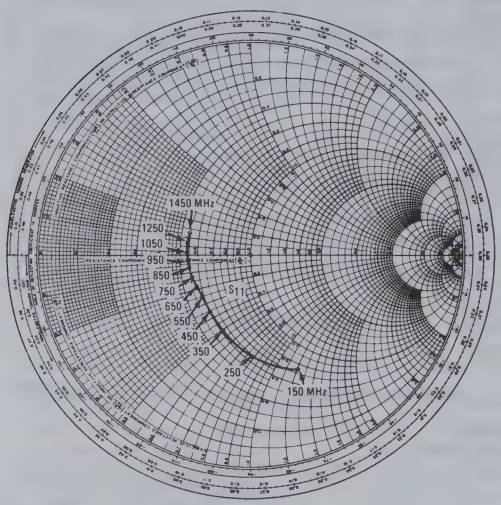


FIGURE 9 – S_{22}, OUTPUT REFLECTION COEFFICIENT

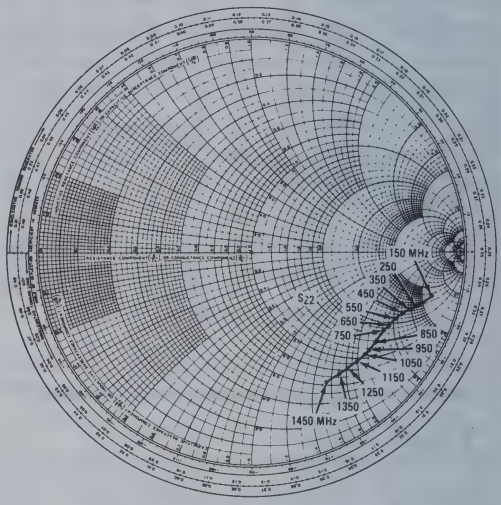


FIGURE 10 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

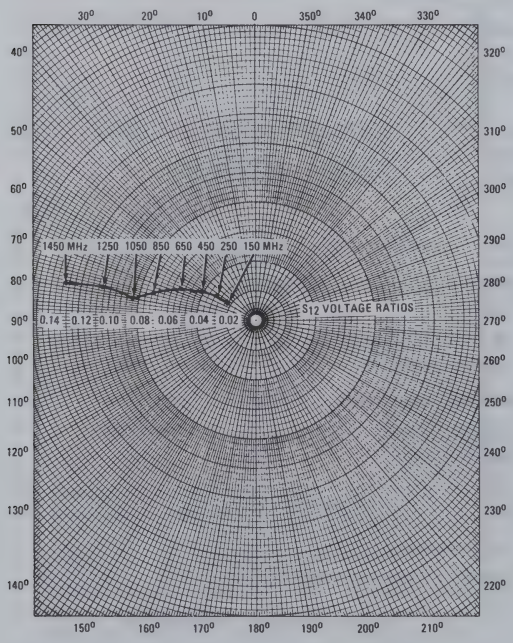
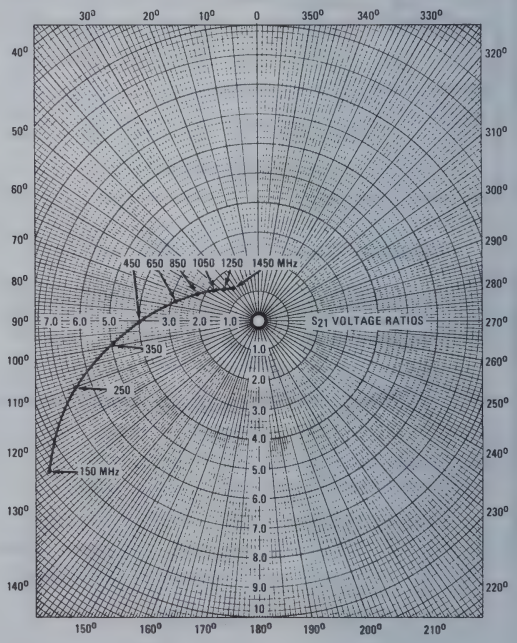


FIGURE 11 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5836 SCATTERING PARAMETERS
(I_C = 100 mAdc, V_{CE} = 10 Vdc, $Z_G = Z_L$ = 50 Ohms)

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

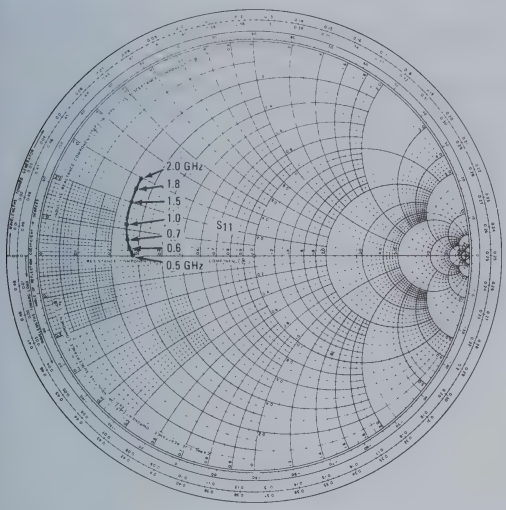


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

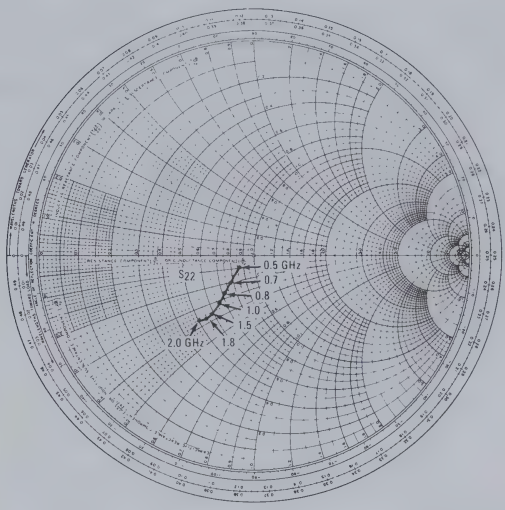


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

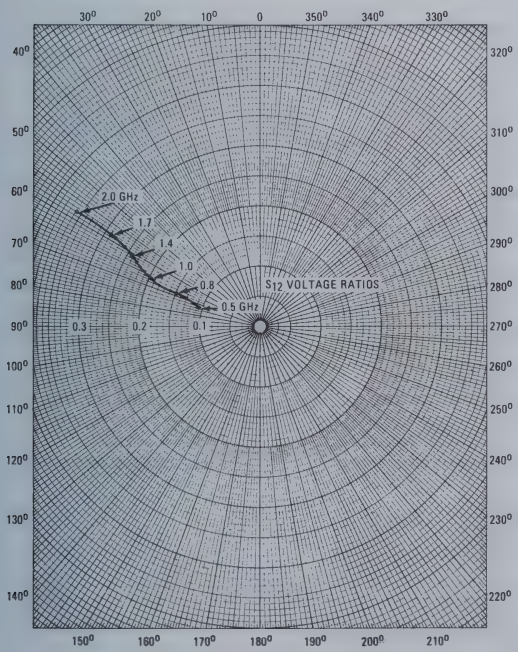
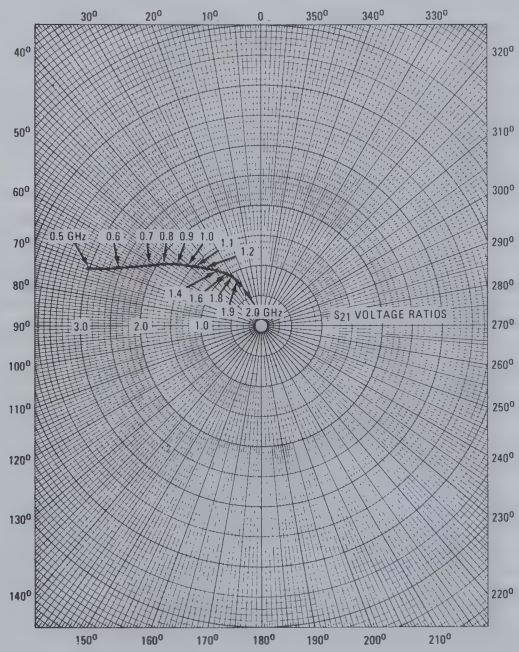


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5837 SCATTERING PARAMETERS
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, $Z_G = Z_L$ = 50 Ohms)

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

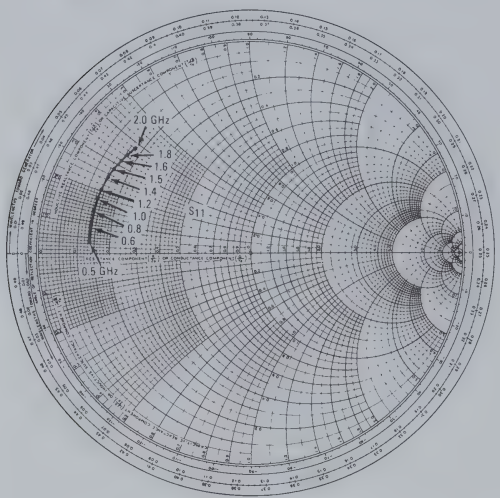


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT

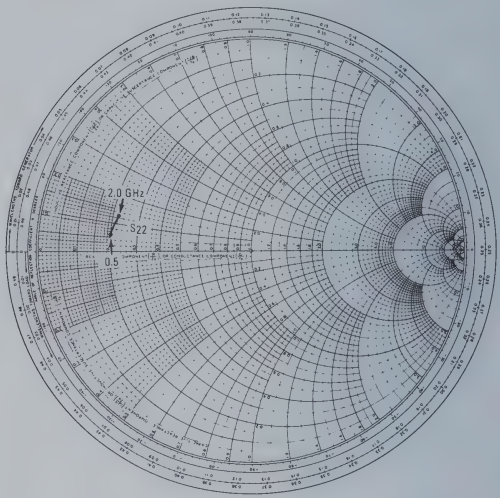


FIGURE 18 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

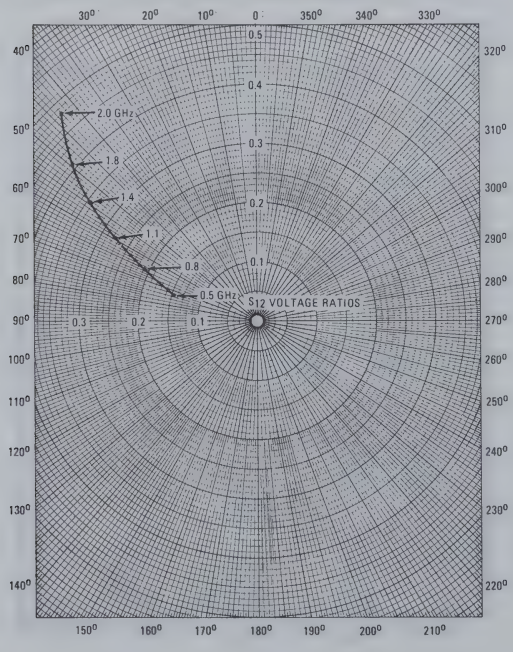
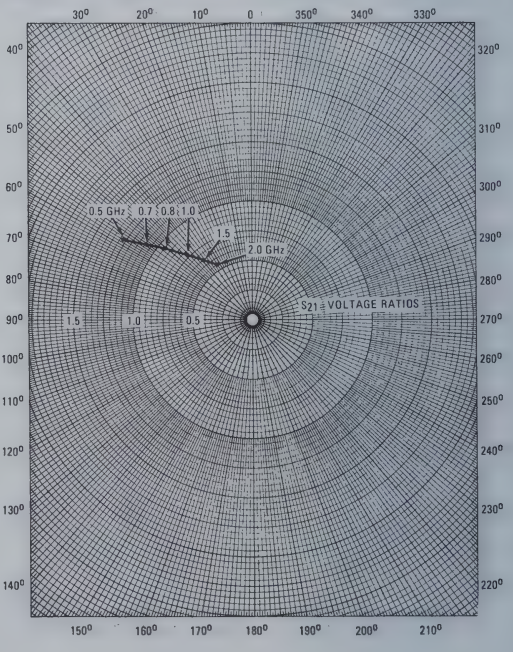


FIGURE 19 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5841 (SILICON)
2N5842

NPN SILICON RF TRANSISTORS

. . . designed to provide ultra-fast switching times in current-mode circuits at collector currents to 80 mAdc.

- High Current-Gain—Bandwidth Product — @ I_C = 25 mAdc
  f_T = 2.2 GHz (Min) 2N5841
  1.7 GHz (Min) 2N5842
- Low Collector-Base Capacitance —
  C_{cb} = 1.5 pF (Max) @ V_{CB} = 4.0 Vdc
- Fast Non-Saturated Switching Times — @ I_C = 30 mAdc
  Typical Values
  $t_{d(on)}$ = 0.4 ns
  t_r = 0.18 ns
  $t_{d(off)}$ = 0.3 ns
  t_f = 0.20 ns

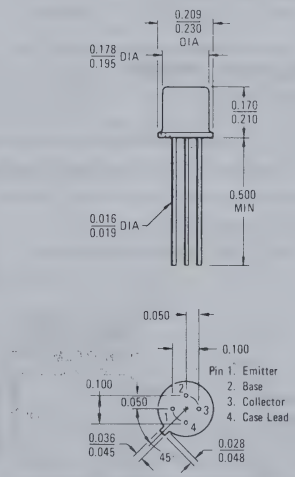
NPN SILICON
RF TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



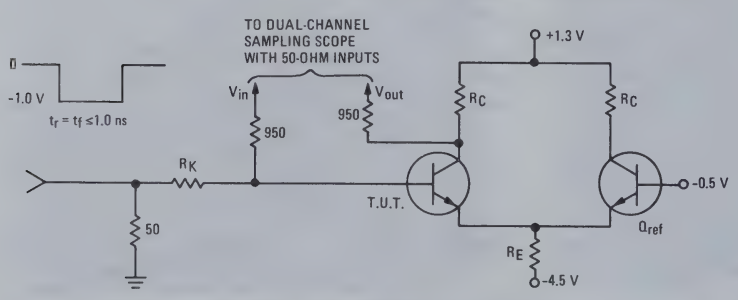
CASE 20 (10)
TO-72 PACKAGE
ACTIVE ELEMENTS ISOLATED FROM CASE

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 25 mAdc, V_{CE} = 4.0 Vdc)	2N5841	h_{FE}	25	–	200	–
	2N5842		25	–	250	
Base-Emitter On Voltage (I_C = 25 mAdc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	–	1.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				GHz
(I_C = 10 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		2.0	2.6	–	
	2N5842		–	2.0	–	
(I_C = 25 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		2.2	2.7	–	
	2N5842		1.7	2.0	–	
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		–	2.2	–	
	2N5842		–	1.5	–	
Collector-Base Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 100 MHz)		C_{cb}	–	0.9	1.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		C_{eb}	–	0.7	1.1	pF
Collector-Base Time Constant		$r_b'C_c$				ps
(I_C = 25 mAdc, V_{CE} = 4.0 Vdc, f = 31.8 MHz)	2N5841		–	18	25	
	2N5842		–	25	40	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(I_C = 30 mAdc)	$t_{d(on)}$	–	0.40	–	ns
Rise Time		t_r	–	0.18	–	ns
Turn-Off Delay Time	(I_C = 30 mAdc)	$t_{d(off)}$	–	0.30	–	ns
Fall Time		t_f	–	0.20	–	ns

*Indicates JEDEC Registered Data

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



V_{in} and V_{out} are attenuated 20:1 at scope inputs. Before attenuation, $V_{in} = V_{out} = 1.0$ V.
Q_{ref} is a transistor of the same type as the transistor under test.

I_C mA	R_E Ohms	R_C Ohms	R_K Ohms
1.0	3.8 k	1.0 k	950
2.0	1.9 k	500	450
4.0	950	250	200
6.0	635	167	117
8.0	475	125	75
10	380	100	50
20	190	50	0
40	95	25	0
60	64	16-17	0
80	48	12-13	0
100	38	10	0

FIGURE 2 – CURRENT GAIN BANDWIDTH PRODUCT

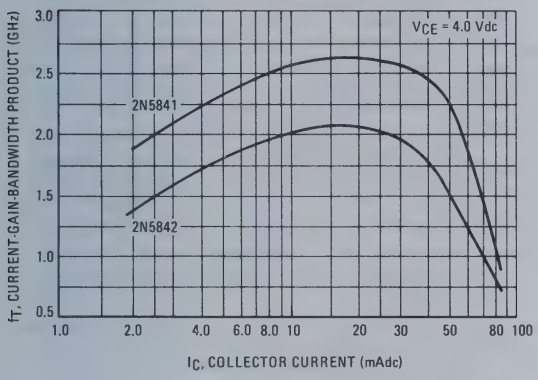


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT

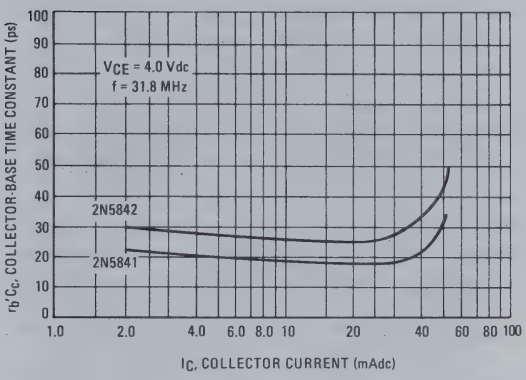


FIGURE 4 – SWITCHING TIMES

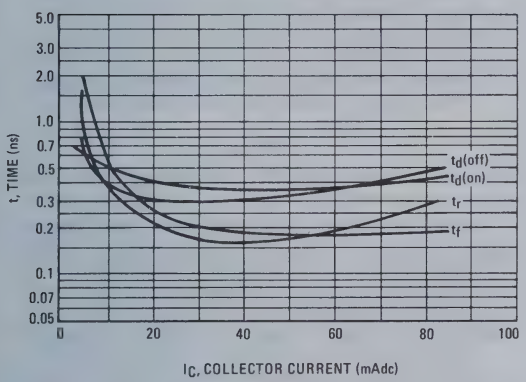


FIGURE 5 – CAPACITANCES

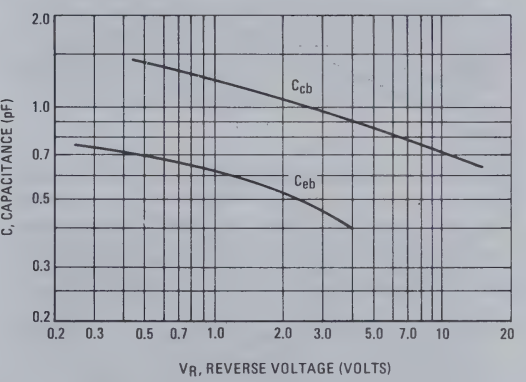


FIGURE 6 – BASE-EMITTER VOLTAGE versus CURRENT

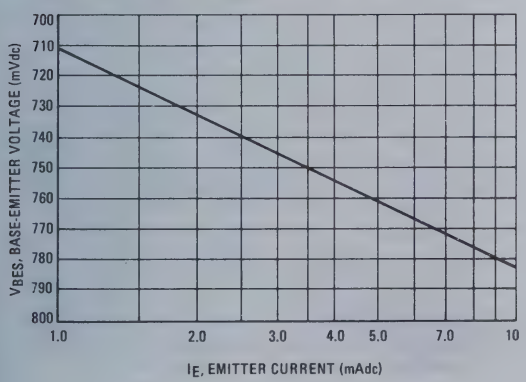
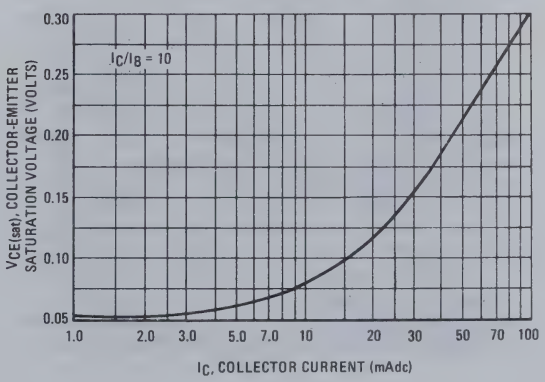


FIGURE 7 – COLLECTOR-EMITTER SATURATION VOLTAGE



V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

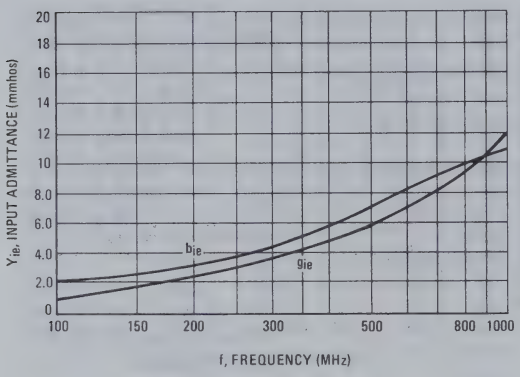


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

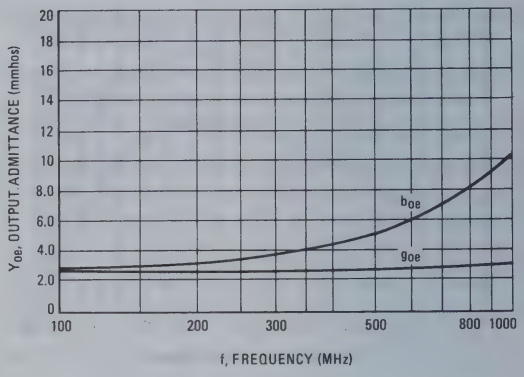


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

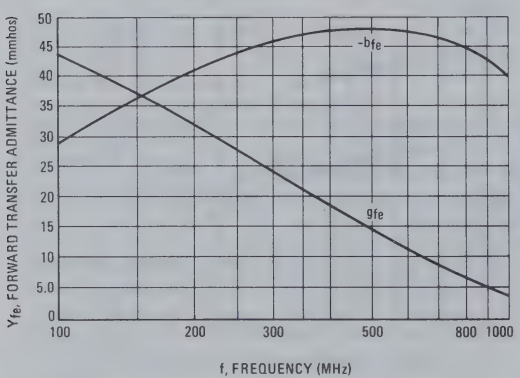
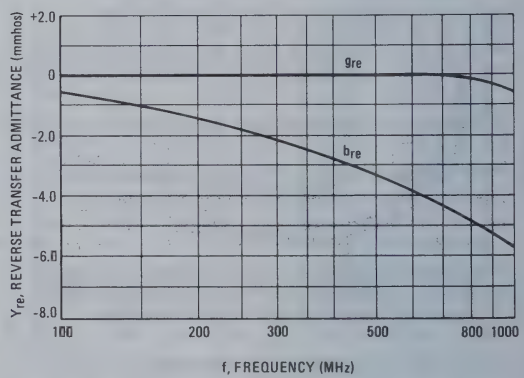
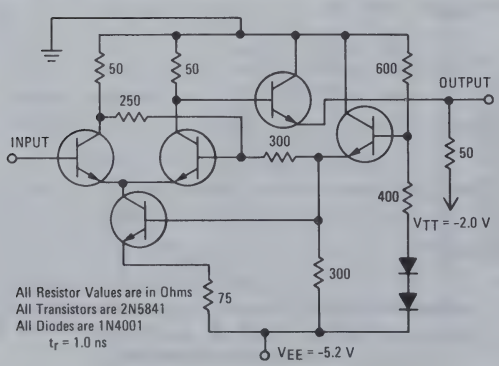


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

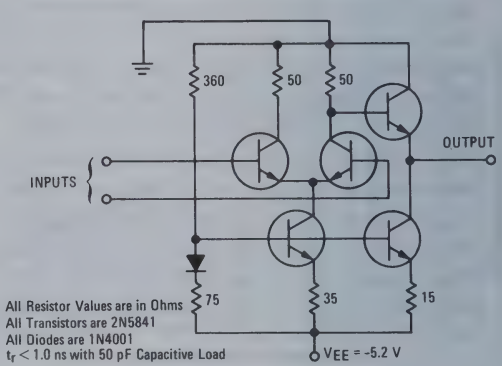


NON-SATURATED SWITCHING APPLICATIONS

SCHMITT TRIGGER



HIGH-SPEED CLOCK DRIVER



V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

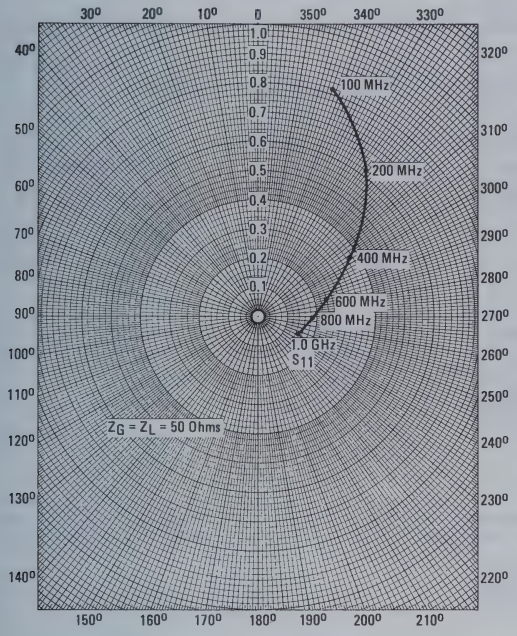


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

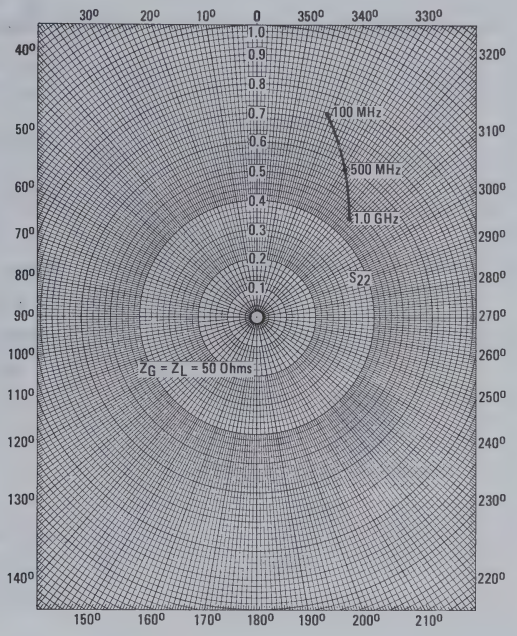


FIGURE 14 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

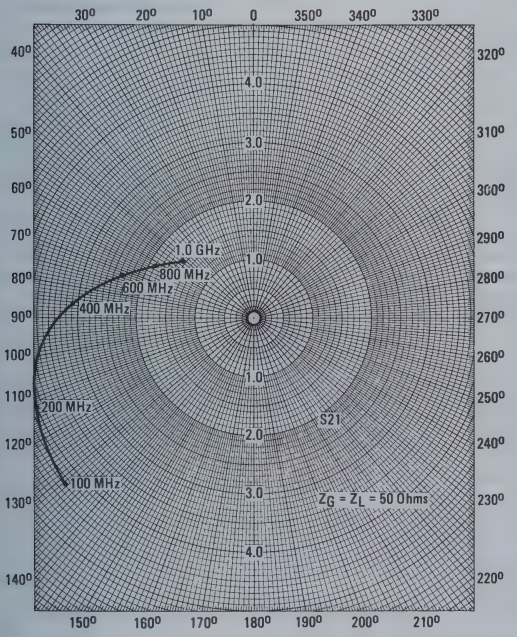
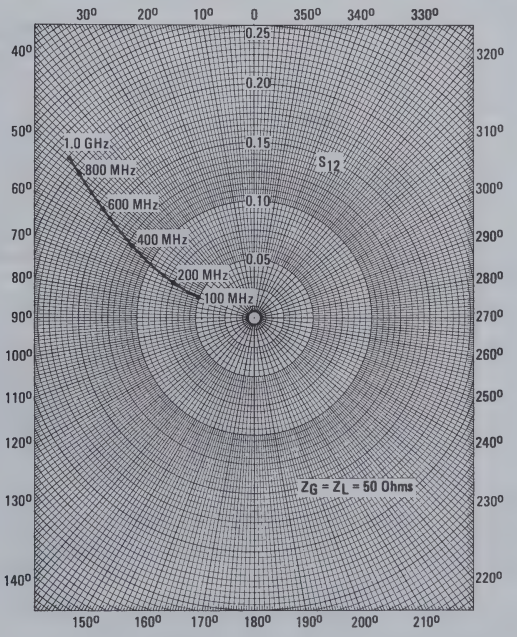


FIGURE 15 – S_{12}, REVERSE TRANSMISSION COEFFICIENT



V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

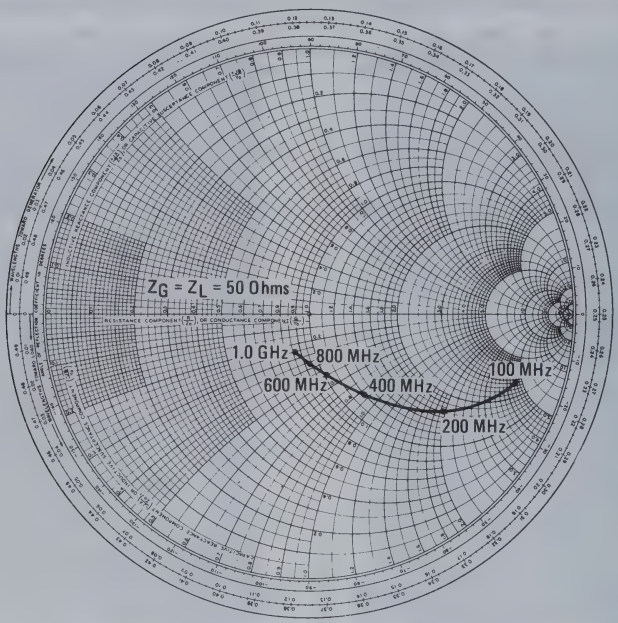
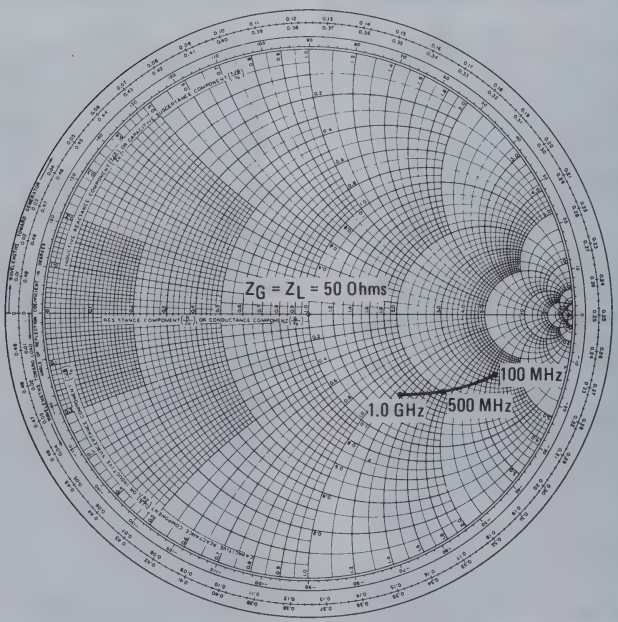


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT



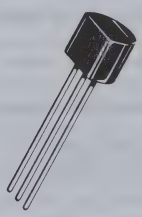
2N5845 (SILICON)
2N5845A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-current saturated switching and core driver applications.

- Fast Switching Times @ I_C = 500 mAdc –
  t_{on} = 30 ns (Max) – 2N5845A
  40 ns (Max) – 2N5845
  t_{off} = 50 ns (Max) – 2N5845A
  60 ns (Max) – 2N5845
- High Current Gain – Bandwidth Product –
  f_T = 250 MHz (Min) – 2N5845A
  200 MHz (Min) – 2N5845
- Low Collector-Emitter Saturation Voltage – @ I_C = 500 mAdc –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) – 2N5845A
  0.6 Vdc (Max) – 2N5845

NPN SILICON SWITCHING TRANSISTORS



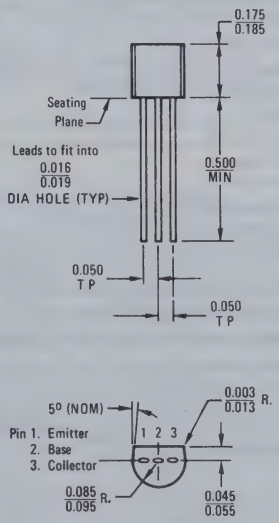
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	°C/W

*Indicates JEDEC Registered Data.



CASE 29-02
TO-92

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

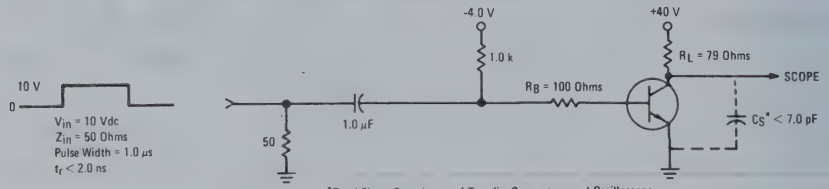
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	–	500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ①		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			50	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	200	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N5845		25	150	
	2N5845A		35	150	
Collector-Emitter Saturation Voltage ①		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.25	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N5845		–	0.6	
	2N5845A		–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.85	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.1	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ② (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N5845	f_T	200	–	MHz
	2N5845A		250	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	9.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	70	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	2N5845	t_{on}	–	40	ns
		2N5845A		–	30	
Delay Time		2N5845	t_d	–	17	ns
		2N5845A		–	15	
Rise Time		2N5845	t_r	–	28	ns
		2N5845A		–	25	
Turn-Off Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	2N5845	t_{off}	–	60	ns
		2N5845A		–	50	
Storage Time		2N5845	t_s	–	40	ns
		2N5845A		–	38	
Fall Time		2N5845	t_f	–	30	ns
		2N5845A		–	27	

*Indicates JEDEC Registered Data.

① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

② f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



*Total Shunt Capacitance of Test Jig, Connectors, and Oscilloscope.

TRANSIENT CHARACTERISTICS

FIGURE 2 – DELAY TIME

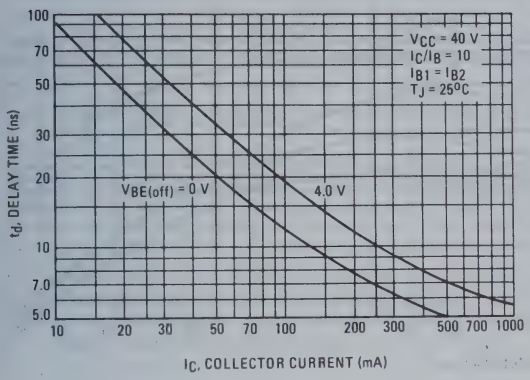


FIGURE 3 – RISE TIME

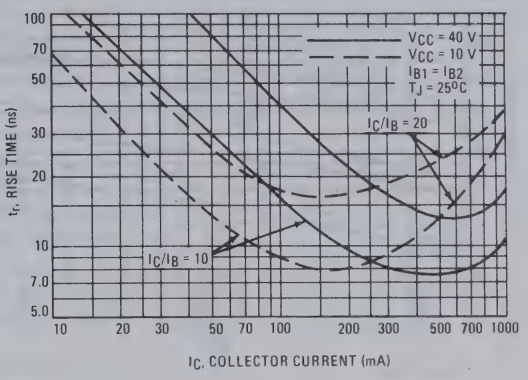


FIGURE 4 – STORAGE TIME

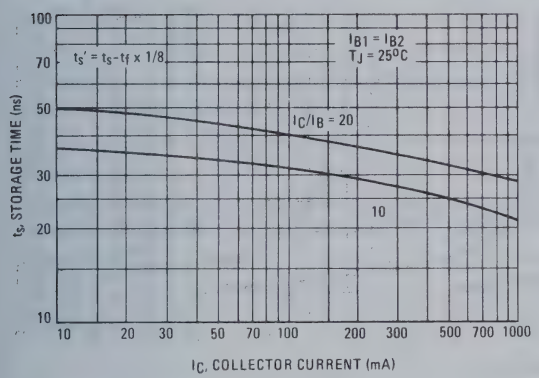


FIGURE 5 – STORAGE TIME CONTOURS

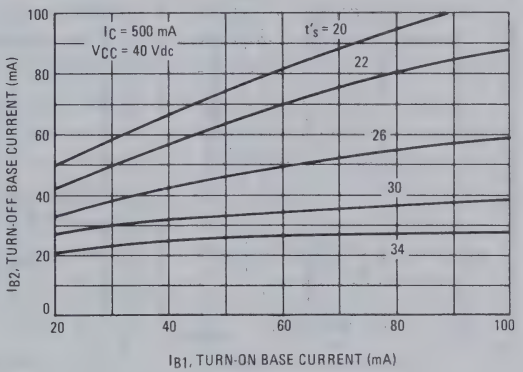


FIGURE 6 – FALL TIME

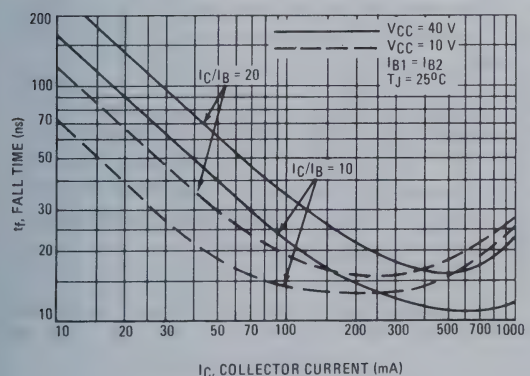
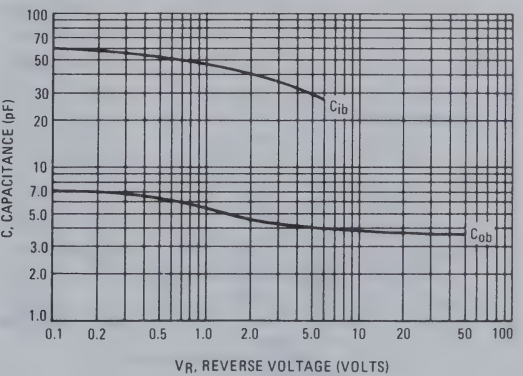


FIGURE 7 – CAPACITANCES



STATIC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

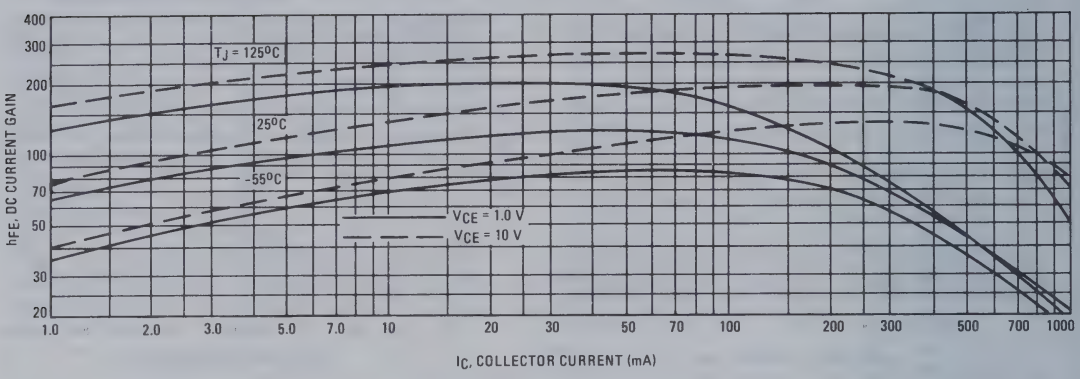


FIGURE 9 – SATURATION REGION

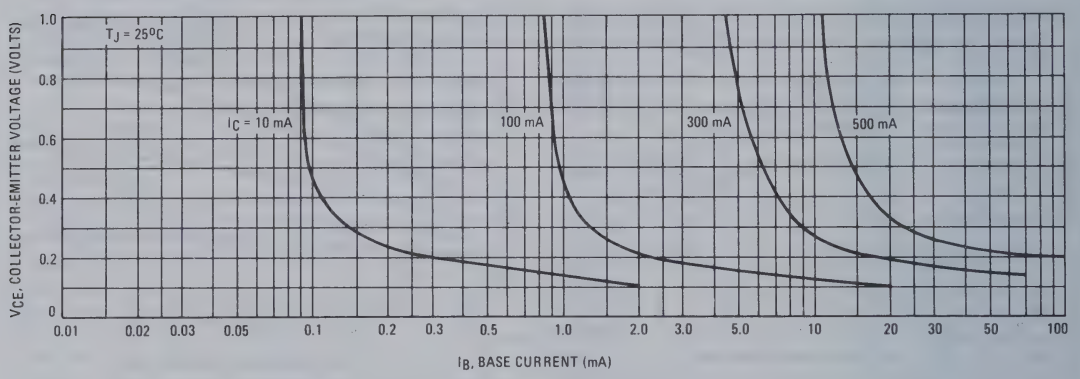


FIGURE 10 – "ON" VOLTAGES

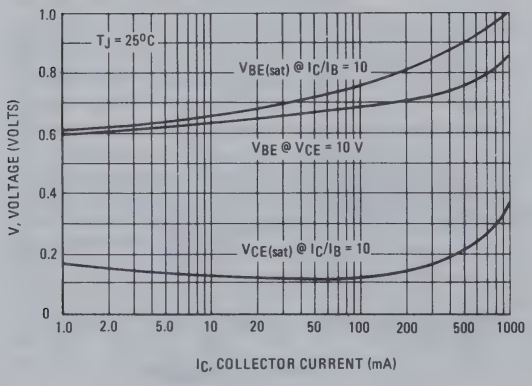
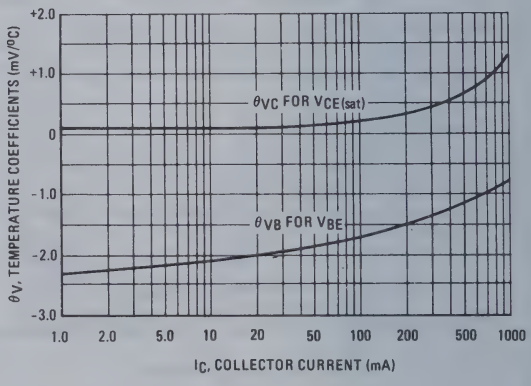


FIGURE 11 – TEMPERATURE COEFFICIENTS



2N5846 (SILICON)
2N5847

The RF Line

NPN SILICON RF POWER TRANSISTORS

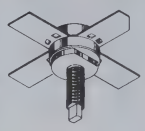
. . . designed primarily for use in large-signal amplifier driver and pre-driver stages, these devices are intended for use in industrial communications equipment operating at frequencies to 80 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- Power Output @ 12.5 Vdc, 50 MHz
  P_{out} = 3.5 W – 2N5846
  8.0 W – 2N5847
- Large-Signal Impedance Data Permit Convenient Matching Network Design

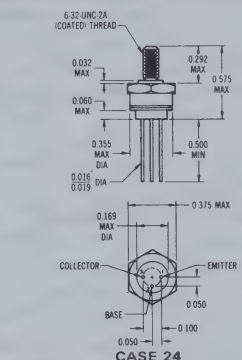
3.5 W, 7.0 W – 50 MHz
RF POWER
TRANSISTORS
NPN SILICON



TO-102
CASE 24



CASE 145A-01

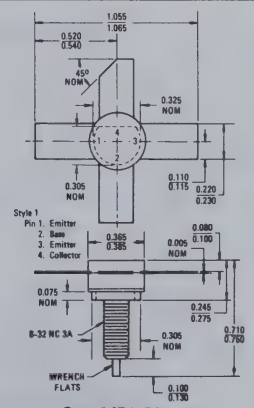


2N5846
CASE 24
TO-102
Collector connected to case; stud isolated from case.

*MAXIMUM RATINGS

Rating	Symbol	2N5846	2N5847	Unit
Collector-Emitter Voltage	V_{CEO}	18		Vdc
Collector-Base Voltage	V_{CB}	36		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57.2	20 114	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.



Case 145A-01
2N5847

POWER OUTPUT versus POWER INPUT

FIGURE 2 – 2N5846

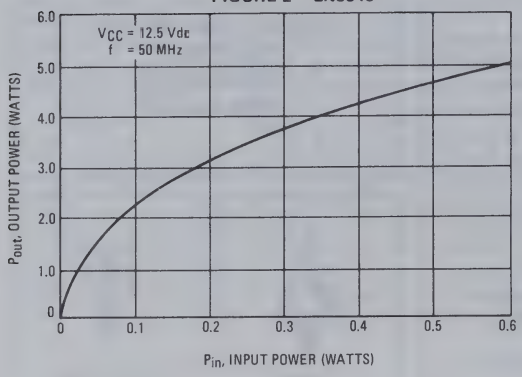
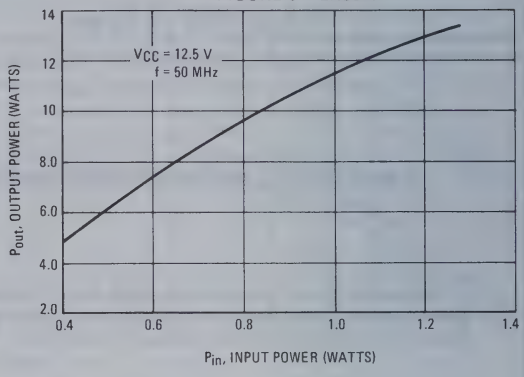


FIGURE 3 – 2N5847



POWER OUTPUT versus FREQUENCY

FIGURE 4 – 2N5846

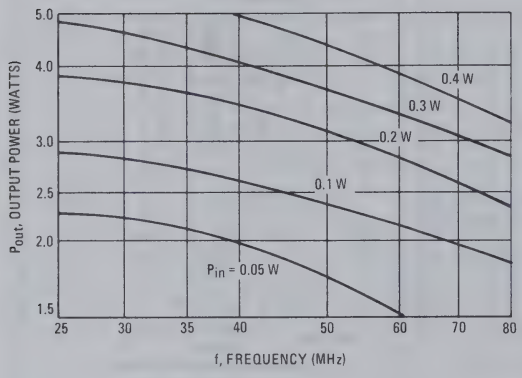
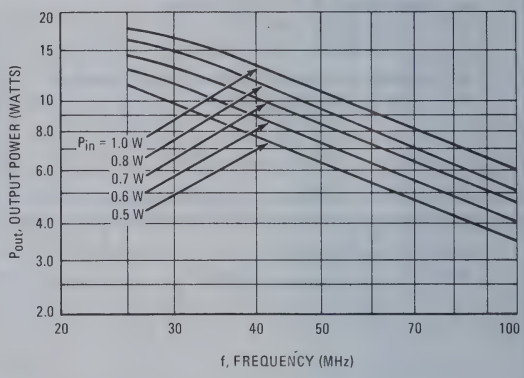


FIGURE 5 – 2N5847



POWER DISSIPATION DERATING CURVES

FIGURE 6 – 2N5846

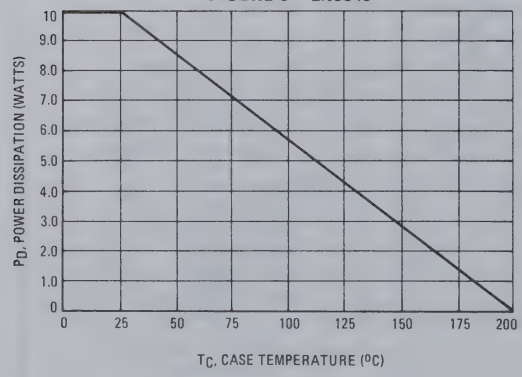
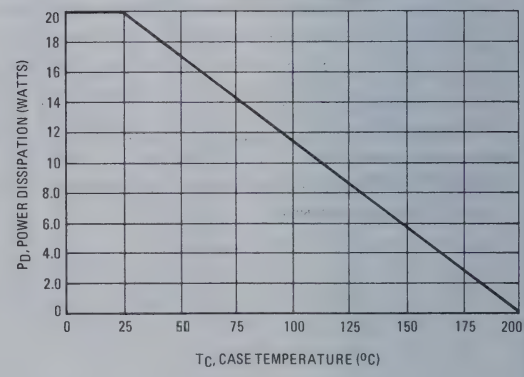


FIGURE 7 – 2N5847



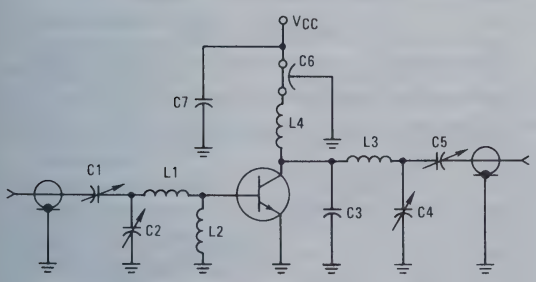
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, I_B = 0)		BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 50 mAdc, V_{BE} = 0)		BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 0.25 mAdc, I_C = 0)	2N5846		4.0	–	
(I_E = 5.0 mAdc, I_C = 0)	2N5847		4.0	–	
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 125°C)	2N5846		–	5.0	
	2N5847		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N5846		–	0.5	
	2N5847		–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	2N5846		5.0	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5847		5.0	–	
DYNAMIC CHARACTERISTICS					
Output Capacitance		C_{ob}			pF
(V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5846		–	25	
	2N5847		–	90	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain		G_{PE}			dB
(V_{CC} = 12.5 Vdc, P_{out} = 3.5 W, f = 50 MHz)	2N5846		10	–	
(V_{CC} = 12.5 Vdc, P_{out} = 8.0 W, f = 50 MHz)	2N5847		10	–	
Power Output		P_{out}			Watts
(V_{CC} = 12.5 Vdc, P_{in} = 350 mW, f = 50 MHz)	2N5846		3.5	–	
(V_{CC} = 12.5 Vdc, P_{in} = 800 mW, f = 50 MHz)	2N5847		8.0	–	
Collector Efficiency		η			%
(V_{CC} = 12.5 Vdc, P_{out} = 3.5 W, f = 50 MHz)	2N5846		50	–	
(V_{CC} = 12.5 Vdc, P_{out} = 8.0 W, f = 50 MHz)	2N5847		50	–	

*Indicates JEDEC Registered Data.
(1)Pulsed thru a 25 mH inductor.

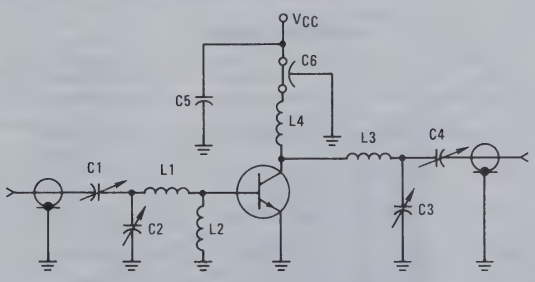
FIGURE 1 – 50 MHz TEST CIRCUITS

2N5846



C1, C2, C5	25-280 pF, Arco 464 or Equivalent
C3	40 pF, 500 Vdc, Unelco
C4	9.0 -180 pF, Arco 463 or Equivalent
C6	1000 pF Feedthru
C7	0.1 μF, 75 Vdc
L1	2 Turns, #18 AWG, 3/8" I.D.
L2	Small Ferrite Bead, 2½ Turns
L3	5 Turns, #18 AWG, 3/8" I.D.
L4	1.0 μH, RF Choke

2N5847



C1, C3, C4	25-280 pF, Arco 464 or Equivalent
C2	80-480 pF, Arco 466 or Equivalent
C5	0.1 μF, 75 Vdc
C6	1000 pF Feedthru
L1	1 Turn, #14 AWG ½" I.D.
L2	Large Ferrite Bead 2½ Turns
L3	3 Turns, #14 AWG ½" I.D.
L4	20 Turns, #18 AWG NYCLAD Wire, 2 Layers (10 Turns Per Layer) ¼" I.D.

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 8 – 2N5846

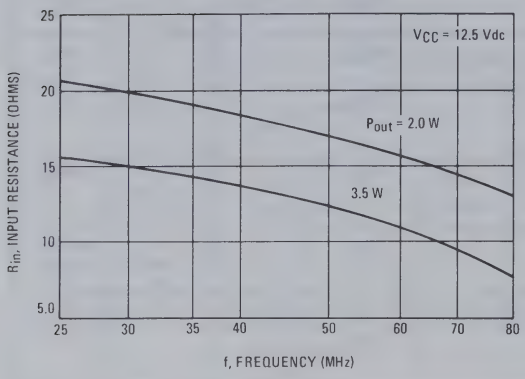
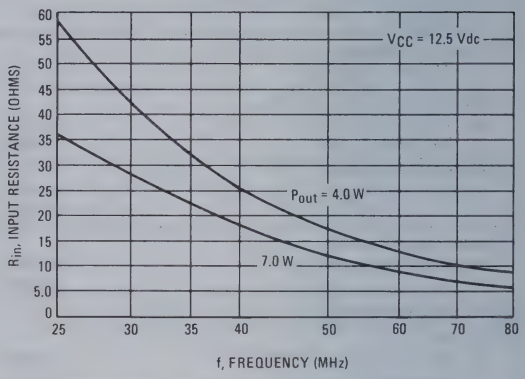


FIGURE 9 – 2N5847



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 10 – 2N5846

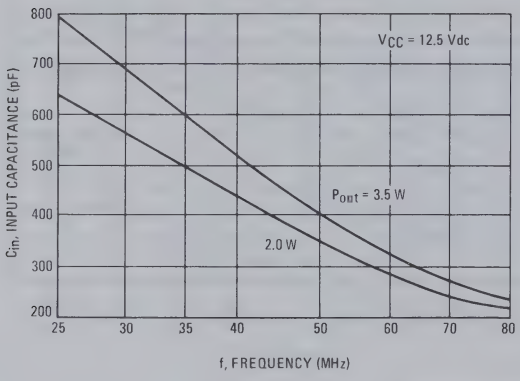
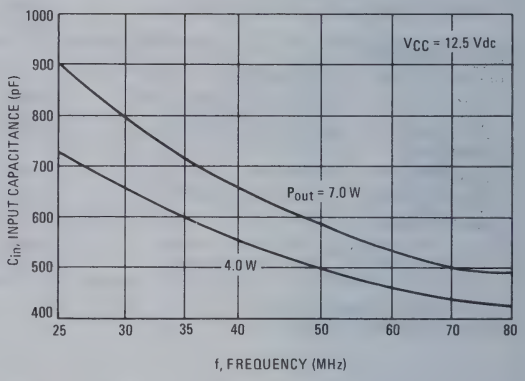


FIGURE 11 – 2N5847



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 12 – 2N5846

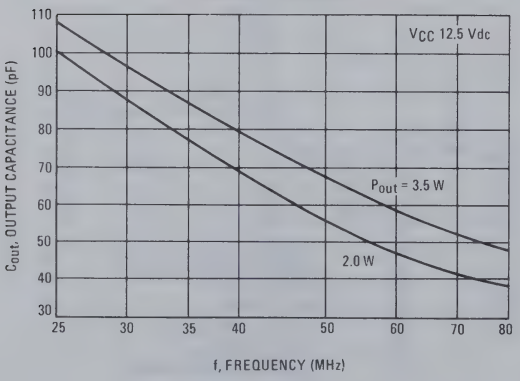
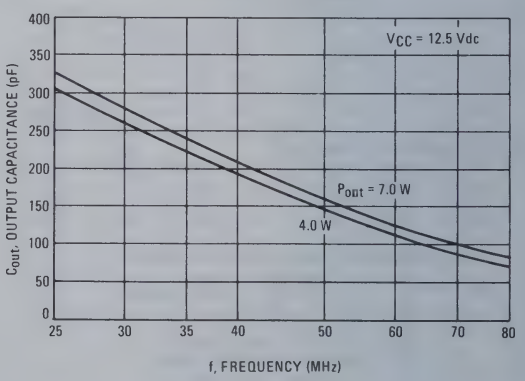


FIGURE 13 – 2N5847



2N5848 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

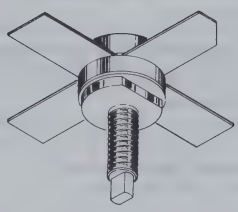
. . . designed primarily for use in large-signal amplifier driver and output stages, the 2N5848 is intended for use in industrial communications equipment operating at frequencies to 80 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- 20 Watts (Min) RF Power Output at 50 MHz
- Balanced Emitter Construction for Burn Out Protection

20 W–50 MHz

RF POWER TRANSISTOR

NPN SILICON

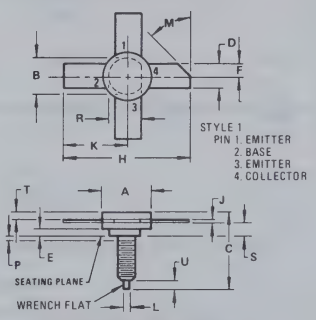


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	24	Vdc
Collector-Base Voltage	V_{CB}	48	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	3.5	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	50 285	Watts $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Stud Torque (1)	—	6.5	in-lbs.

*Indicates JEDEC Registered Data.

(1) For repeated assembly use 5 in-lbs.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	26.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE
CASE 145A 01 USE 8 32NC2A STUD

CASE 145A-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	24	–	–	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	48	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +125°C)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.2 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	3.0	15	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	100	125	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (P_{out} = 20 W, V_{CC} = 12.5 Vdc, I_C = 3.2 Adc, f = 50 MHz)	G_{PE}	8.0	–	–	dB
Collector Efficiency (P_{out} = 20 W, V_{CC} = 12.5 Vdc, I_C = 3.2 Adc, f = 50 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
(1)Pulsed thru a 25 mH Inductor.

FIGURE 1 – 50 MHz POWER GAIN TEST CIRCUIT

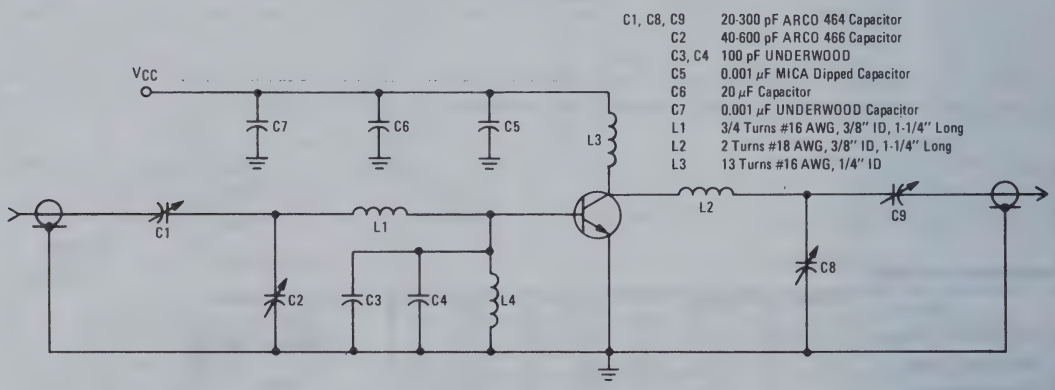


FIGURE 2 – OUTPUT POWER versus INPUT POWER

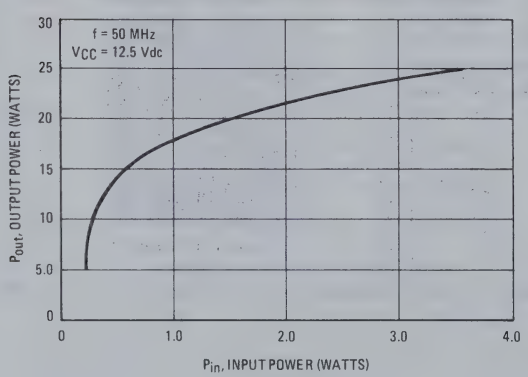


FIGURE 3 – OUTPUT POWER versus FREQUENCY

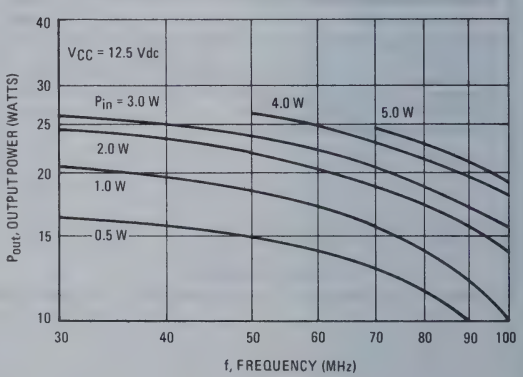


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

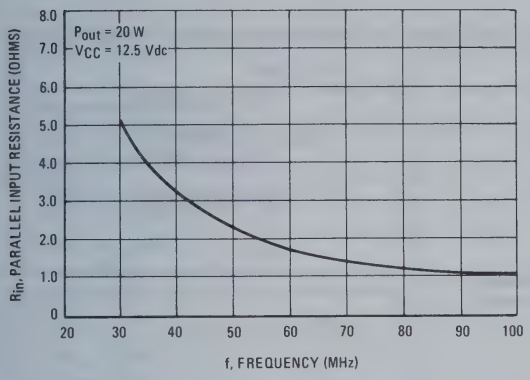


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

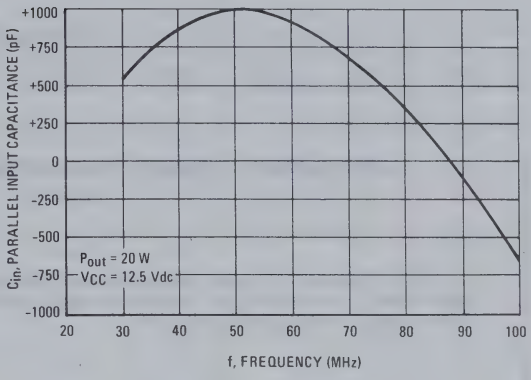


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

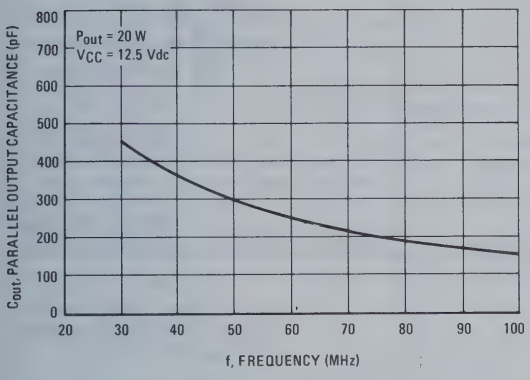
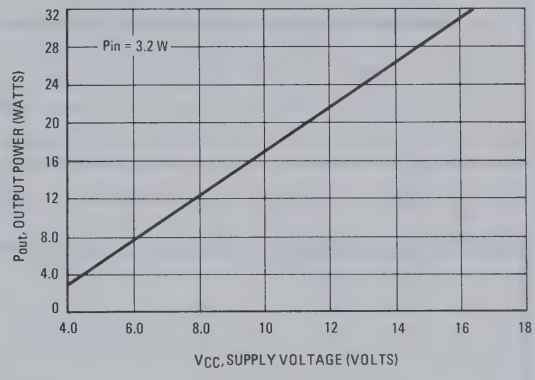
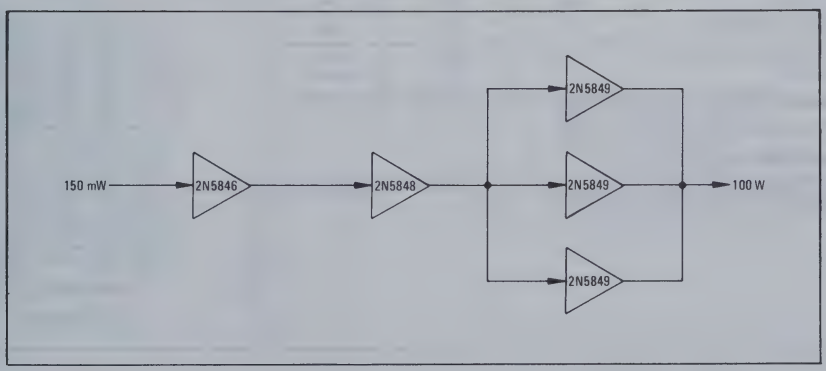


FIGURE 7 – OUTPUT POWER versus SUPPLY VOLTAGE



LOW-BAND FM (25-50 MHz) 12.5 Vdc, 100 WATT AMPLIFIER



2N5849 (SILICON)

NPN SILICON RF POWER TRANSISTOR

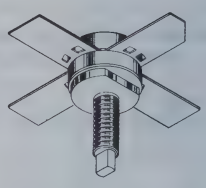
. . . designed primarily for use in large-signal amplifier output stages, the 2N5849 is intended for use in industrial communications equipment operating at frequencies to 80 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- 40 Watts (Min) RF Power Output at 50 MHz
- Balanced Emitter Construction for Burn Out Protection

40 W–50 MHz

RF POWER TRANSISTOR

NPN SILICON

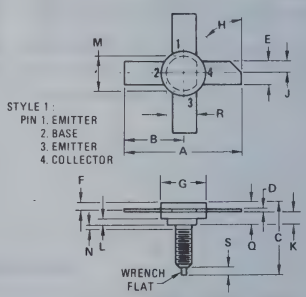


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	24	Vdc
Collector-Base Voltage	V_{CB}	48	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	7.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	100 571	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.

This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.055	1.065	26.79	27.05
B	.520	.530	13.20	13.71
C	.835	.845	21.20	21.45
D	.0045	.006	.114	.152
E	.221	.229	5.61	5.82
F	.080	.090	2.03	2.89
G	.495	.508	12.57	12.90
H	45° NOM		45° NOM	
J	.110	.115	2.79	2.93
K	.153	.175	3.89	4.45
L	.072	.078	1.83	1.98
M	.415	.425	10.54	10.80
N	–	.050	–	1.27
Q	.245	.275	6.31	6.89
R	.385	.394	9.78	10.01
S	.100	.130	2.54	3.30

NOTE:
CASE 145A-02 USE 10-32NC2A STUD

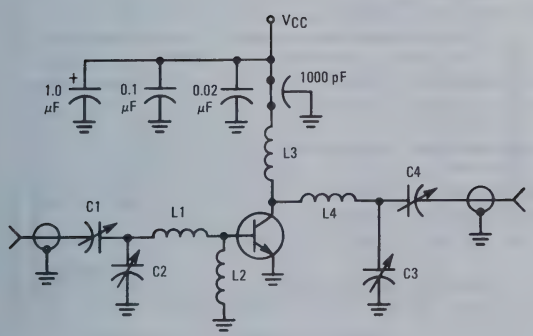
CASE 145A-02

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	24	–	–	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	48	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +125°C)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	3.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	180	230	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 50 MHz)	G_{PE}	7.5	–	–	dB
Collector Efficiency (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 50 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
(1)Pulsed thru a 25 mH Inductor.

FIGURE 1 – 50 MHz POWER GAIN TEST CIRCUIT



C1 25-280 pF, Arco 464 or Equivalent
C2 80-480 pF, Arco 466 or Equivalent
C3 0-75 pF, Hammarlund MAPC 75 or Equivalent
C4 0-50 pF, Hammarlund MAPC 50 or Equivalent
L1 1 Turn #14 AWG 5/16" I.D.
L2 2-1/2 Turns #22 AWG on 3/8" Ferrite Bead
L3 18 Turns #18 AWG 3/8" I.D. 2 Layers, 9 Turns Each
L4 4 Turns #14 AWG 7/16" I.D. 7/16" Long

FIGURE 2 – POWER OUTPUT versus POWER INPUT

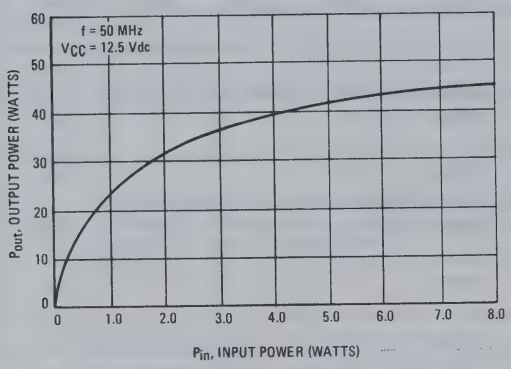


FIGURE 3 – POWER OUTPUT versus FREQUENCY

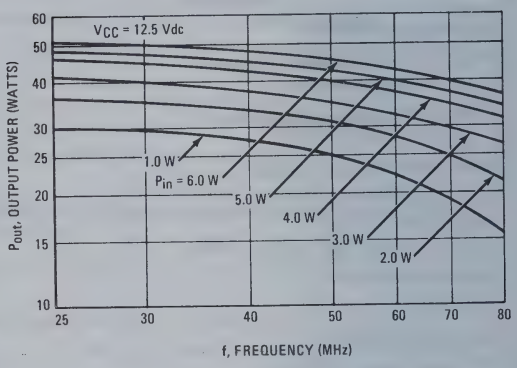


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

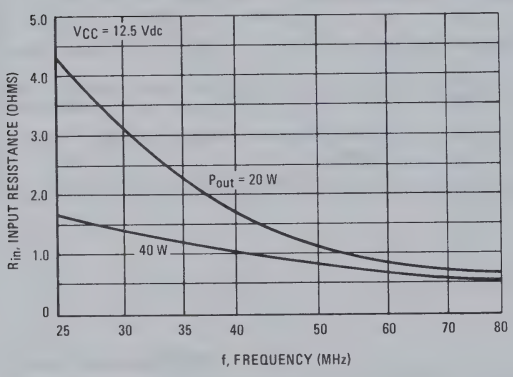


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

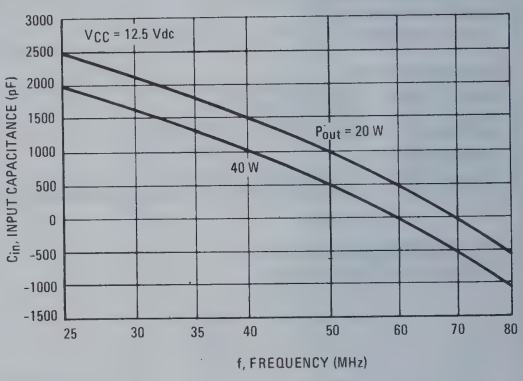


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

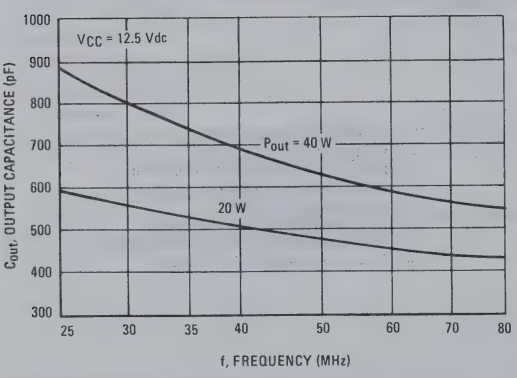
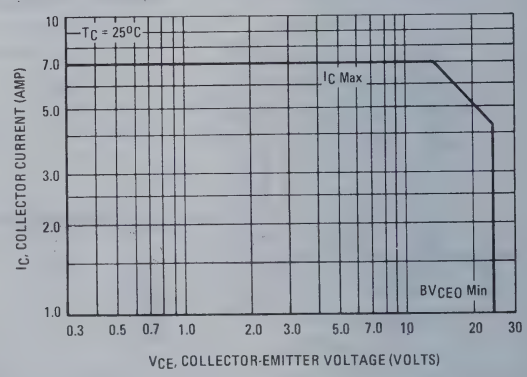
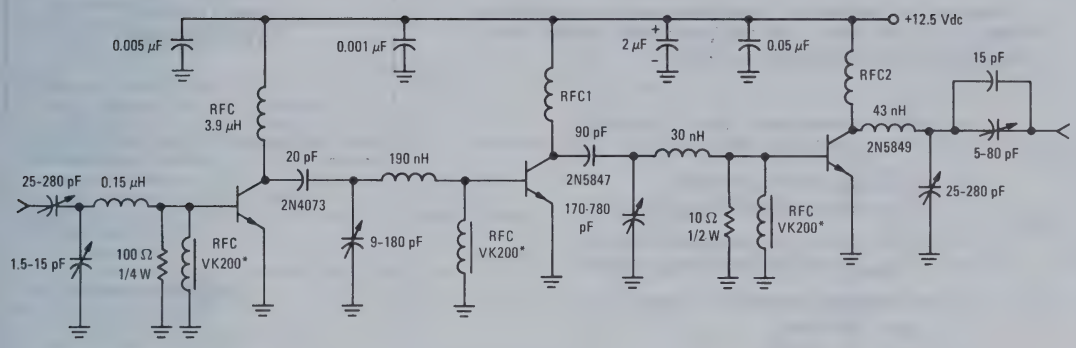


FIGURE 7 – DC SAFE OPERATING AREA



40 WATT, 50 MHz TRANSMITTER SCHEMATIC
(Information obtained from AN-502A)



P_o = 40 W
P_{in} = 20 mW
Overall Gain = 33 dB
Overall Efficiency = 59.2%

*Ferroxcube Part Number
RFC1 – 20 Turns #18 AWG, 3/16" I.D., 2 Layers, 10 Turns Each, Close Wound.
RFC2 – 18 Turns, #18 AWG, 3/16" I.D., 2 Layers, 9 Turns Each, Close Wound.

APPLICATION INFORMATION

In addition to a fine selection of quality RF Semiconductors, Motorola provides applications information in the form of Application Notes. Any of the notes listed on this page may be obtained by writing to the Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Arizona 85036.

AN-267	Matching Network Designs with Computer Solutions
AN-282A	Systemizing RF Power Amplifier Design
AN-481	A Broadband 4-Watt Aircraft Transmitter
AN-495	A 25-Watt, 175-MHz Transmitter for 12.5-Volt Operation
AN-502A	A 40-Watt, 50-MHz Transmitter for 12.5-Volt Operation
AN-503	A 25-Watt Broadband Aircraft Transmitter
AN-507	A 13-Watt Broadband AM Aircraft Transmitter

2N5859 (SILICON)

NPN SILICON ANNULAR♦ SWITCHING TRANSISTOR

. . . designed for high-current, high-speed switching applications. Ideally suited for ferrite core and plated wire memory driver, hammer driver, or MOS translator applications.

- Excellent Current-Gain — Bandwidth Product — f_T = 250 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Base Capacitance — C_{cb} = 7.0 pF (Max) @ V_{CB} = 10 Vdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- Fast Switching Times @ I_C = 1.0 Adc
  t_{on} = 35 ns (Max)
  t_{off} = 60 ns (Max)

NPN SILICON SWITCHING TRANSISTOR



*MAXIMUM RATINGS

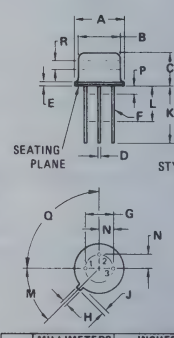
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

*Indicates JEDEC Registered Data

♦Annular Semiconductors Patented by Motorola Inc.



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

CASE 79-02
TO-39
All JEDEC notes and dimensions apply.

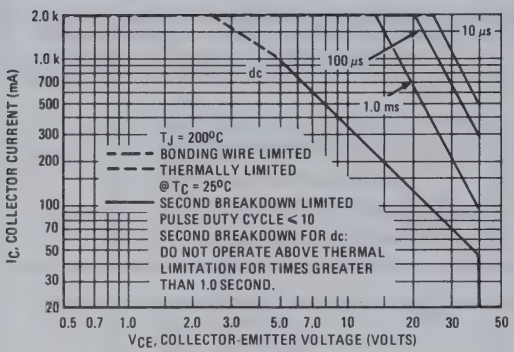
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	80	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc) (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_A = 75°C)	I_{CEX}	 – –	 0.2 5.0	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 75°C)	I_{CBO}	 – –	 0.25 5.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc, T_A = -55°C)	h_{FE}	 30 15 10	 120 100 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	 – –	 0.4 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	 0.8 0.9	 1.0 1.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	7.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	60	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_{on}	–	35	ns
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_d	–	6.0	ns
Rise Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figures 8 and 10)	t_r	–	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_{off}	–	60	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_s	–	35	ns
Fall Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figures 9 and 11)	t_f	–	35	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

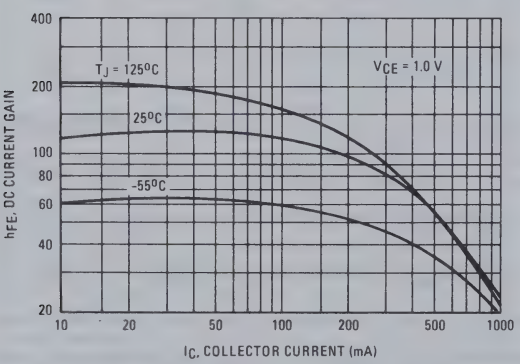


FIGURE 3 – "ON" VOLTAGES

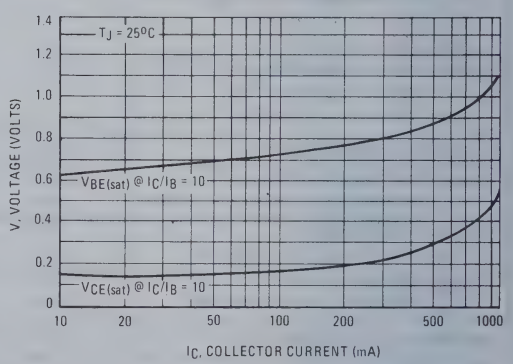


FIGURE 4 – COLLECTOR SATURATION REGION

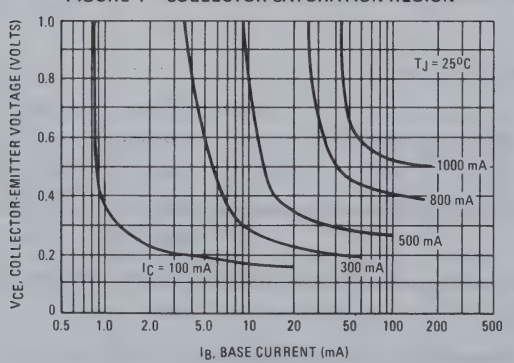
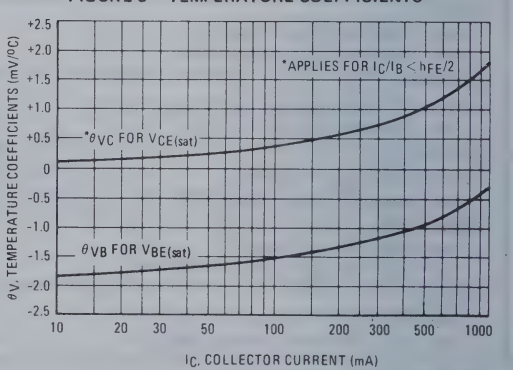


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

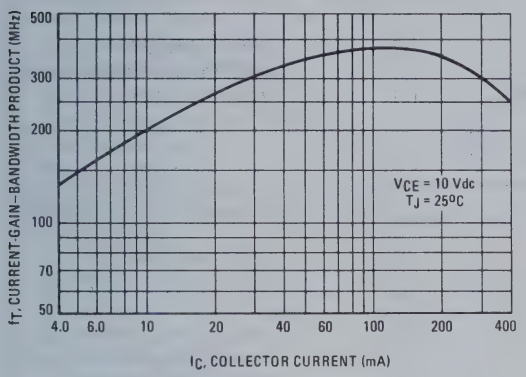


FIGURE 7 – CAPACITANCE

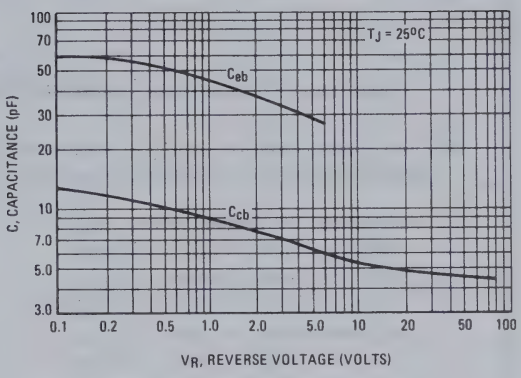


FIGURE 8 – TURN-ON TIME

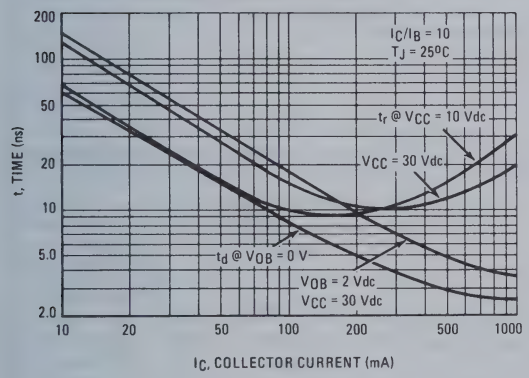


FIGURE 9 – TURN-OFF TIME

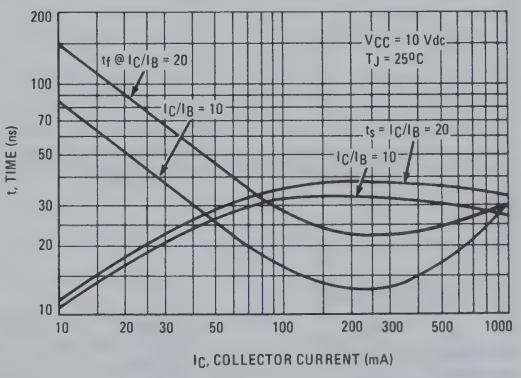


FIGURE 10 – TURN-ON TIME TEST CIRCUIT

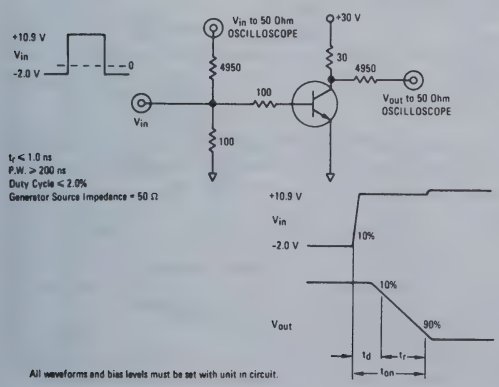
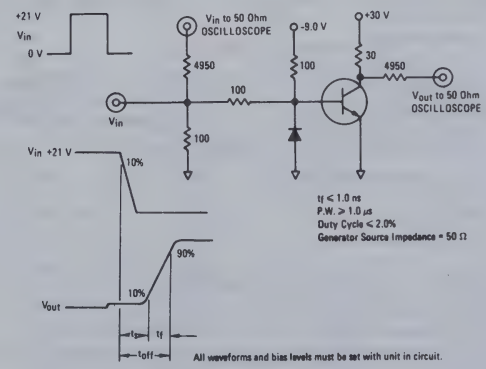


FIGURE 11 – TURN-OFF TIME TEST CIRCUIT



2N5861 (SILICON)

NPN SILICON ANNULAR MEMORY DRIVER

. . . designed for medium-current, high-speed switching applications. Ideally suited for ferrite core memory driver circuits.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc
- Low Collector-Base Capacitance —
  C_{cb} = 7.0 pF (Max) @ V_{CB} = 10 Vdc
- Fast Switching Times @ I_C = 500 mAdc —
  t_{on} = 25 ns (Max)
  t_{off} = 60 ns (Max)

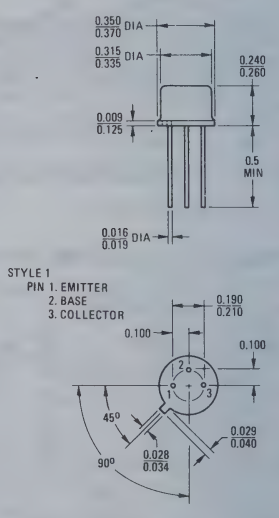
NPN SILICON MEMORY DRIVER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 6.0	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data



All JEDEC dimensions and notes apply

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	I_{CEX}	–	0.3	μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_A = 75°C)		–	10	
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	0.3	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +75°C)		–	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	100	–
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		10	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	7.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	60	pF
SWITCHING CHARACTERISTICS				
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figure 1)	t_{on}	–	25 ns
Delay Time		t_d	–	8.0 ns
Rise Time		t_r	–	18 ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figure 2)	t_{off}	–	60 ns
Storage Time		t_s	–	35 ns
Fall Time		t_f	–	35 ns

*Indicates JEDEC Registered Data.

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

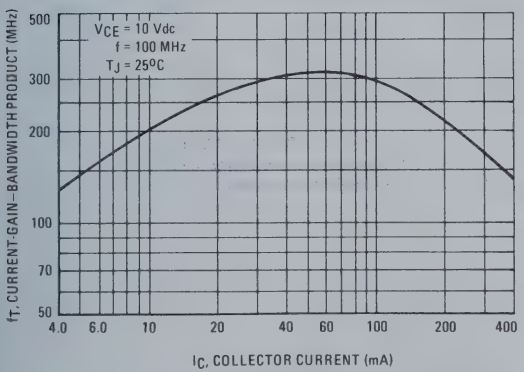
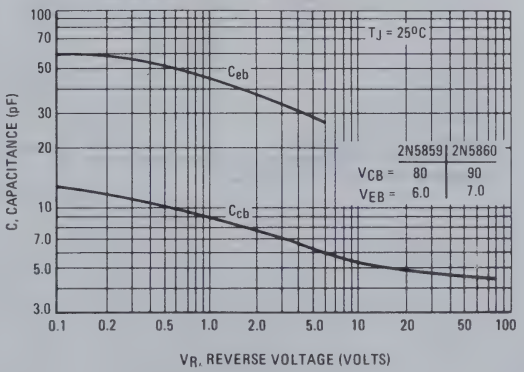


FIGURE 2 – CAPACITANCE



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 3 – TURN-ON TIME

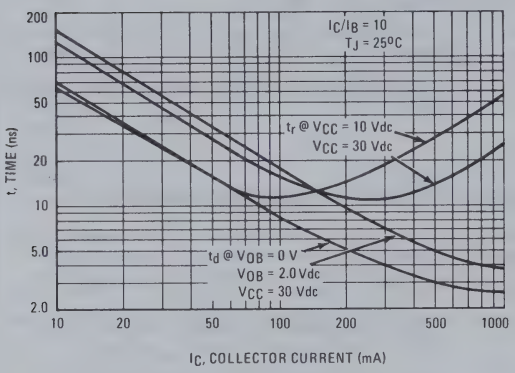


FIGURE 4 – TURN-OFF TIME

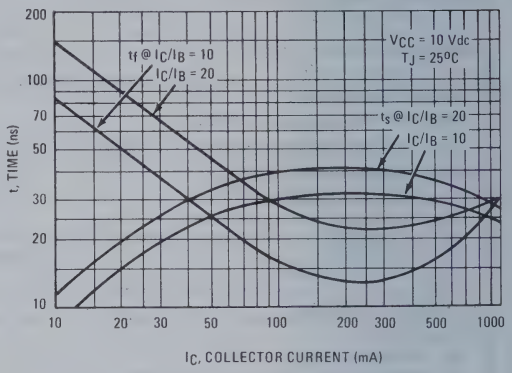
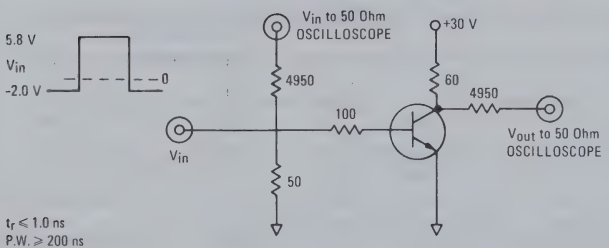
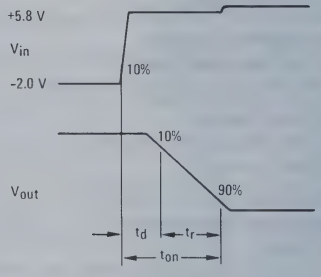


FIGURE 5 – TURN-ON TIME TEST CIRCUIT

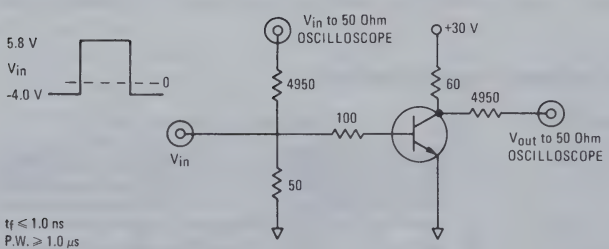


$t_r \leq 1.0$ ns
P.W. $\geq$ 200 ns
Duty Cycle $\leq$ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope

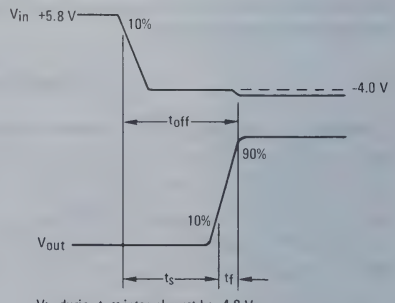


V_{in} during t_{on} interval must be +5.8 V.
All waveforms and bias levels must be set with unit in circuit.

FIGURE 6 – TURN-OFF TIME TEST CIRCUIT



$t_f \leq 1.0$ ns
P.W. $\geq 1.0\ \mu s$
Duty Cycle $\leq$ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator: EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope: Tektronix 661 Sampling Scope



V_{in} during t_{off} interval must be –4.0 V.
All waveforms and bias levels must be set with unit in circuit.

FIGURE 7 – DC CURRENT GAIN

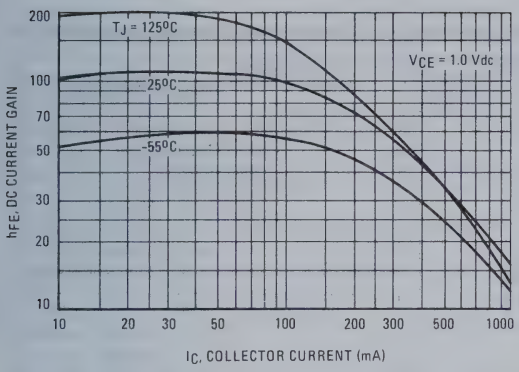


FIGURE 8 – "ON" VOLTAGES

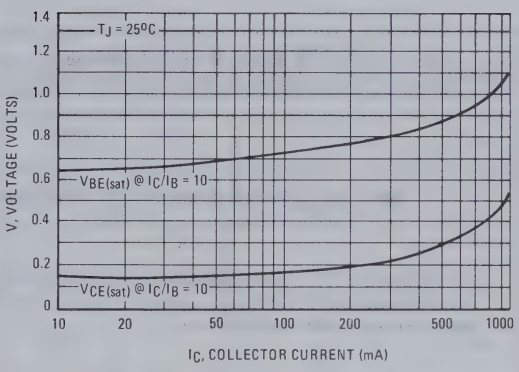
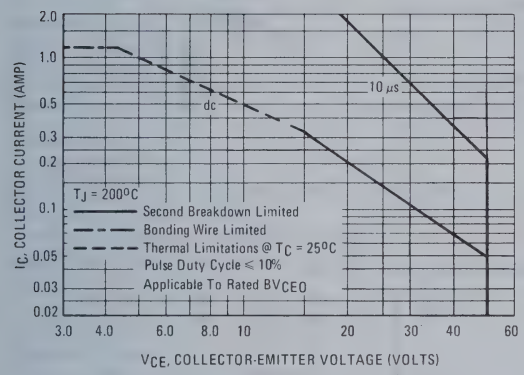


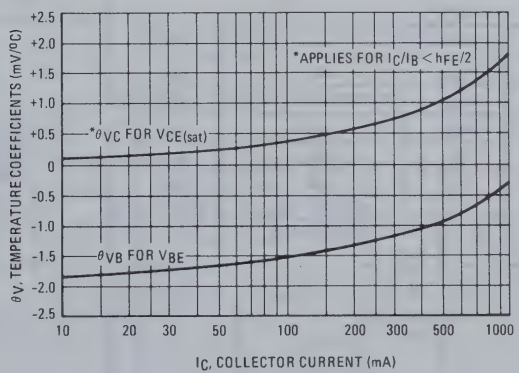
FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 9 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 – TEMPERATURE COEFFICIENTS



2N5862 (SILICON)

The RF Line

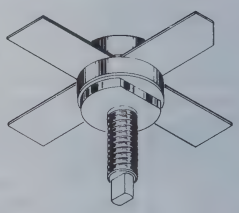
NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

- High Output Power Capability –
  90 Watts Peak Output for 15 Watts (Typ) Input @ f = 150 MHz
- Balanced Emitter Construction to Provide the Designer with the device Technology that Assures Ruggedness and Resists Transistor Damage Caused by Load Mismatch.
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

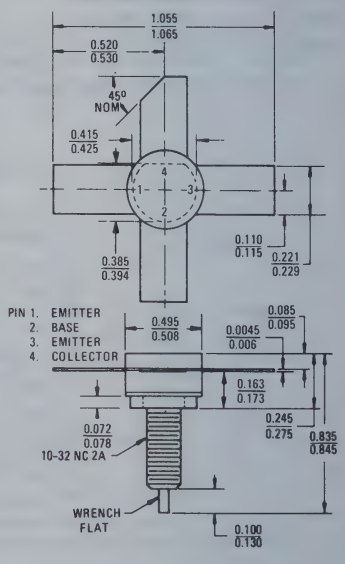
90 WATTS PEAK - 150 MHz

NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C=50°C Derate above 50°C	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



To convert inches to millimeters multiply by 25.4

CASE 145A-02

*Indicates JEDEC Registered Data

*** ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 125°C)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	90	130	pF

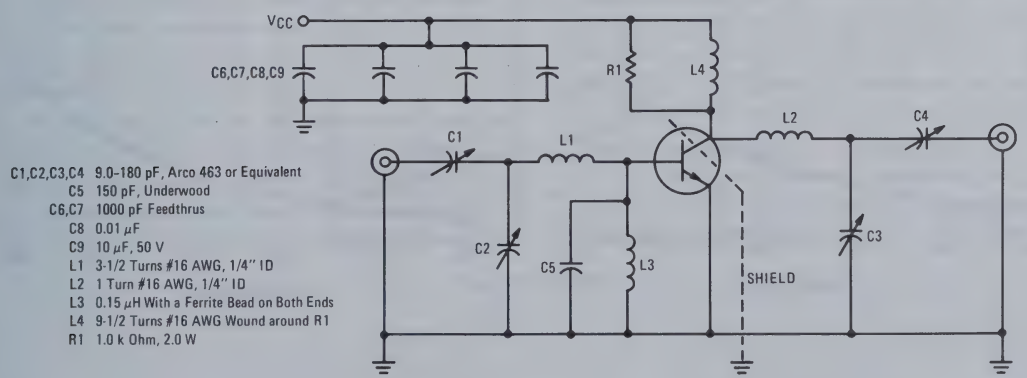
FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CC} = 27 Vdc and not retuned for 13.5 Vdc Carrier Power Test)

Power Input (P_{out} = 90 W Peak, V_{CC} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	15	–	Watts
Power Gain CW (Carrier Power) (P_{out} = 24 W, V_{CC} = 13.5 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CC} = 27 Vdc)	G_{PE}	5.0	–	–	dB
Power Gain (V_{CC} = 27 Vdc, f = 150 MHz, P_{out} = 75 W, I_C = 4.1 Adc, Circuit Tuned at 90 W Peak, V_{CC} = 27 Vdc)	G_{PE}	7.0	–	–	dB
Collector Efficiency (P_{out} = 75 W, V_{CC} = 27 Vdc, f = 150 MHz, I_C = 4.1 Adc)	η	60	–	–	%
Load Mismatch (P_{out} = 75 W, CW, V_{CC} = 27 Vdc, f = 150 MHz, 10% Duty Cycle, 10 ms Pulse, VSWR 10:1, all angles)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

*Indicates JEDEC Registered Data

FIGURE 1 – 150 MHz TEST CIRCUIT



OUTPUT POWER versus FREQUENCY

FIGURE 2 – V_{CC} = 13.5 Vdc

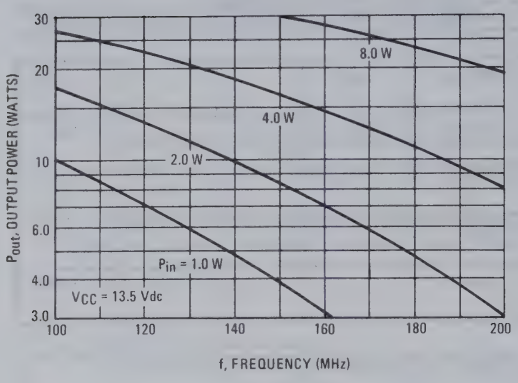


FIGURE 3 – V_{CC} = 27 Vdc

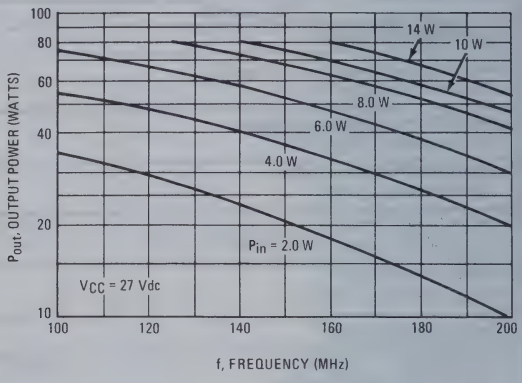


FIGURE 4 – OUTPUT POWER versus INPUT POWER

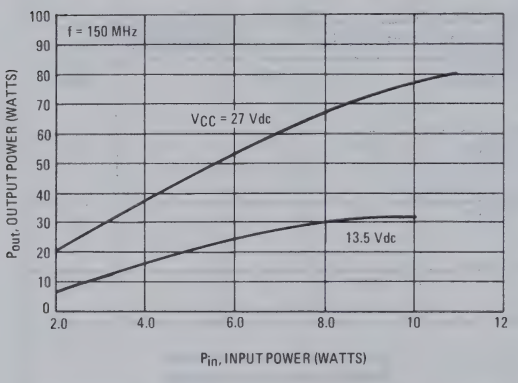
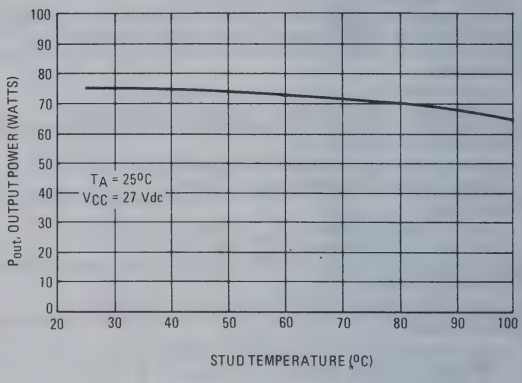


FIGURE 5 – OUTPUT POWER versus STUD TEMPERATURE



PARALLEL INPUT RESISTANCE versus FREQUENCY

FIGURE 6 – V_{CC} = 13.5 Vdc, P_{out} = 25 W

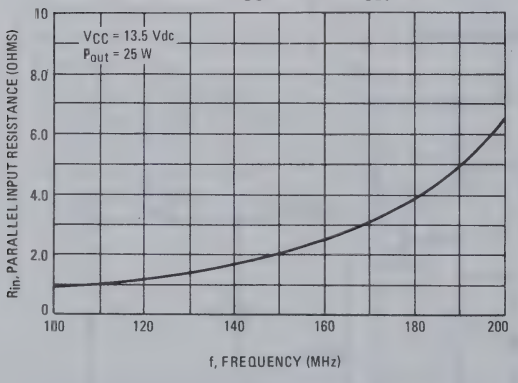
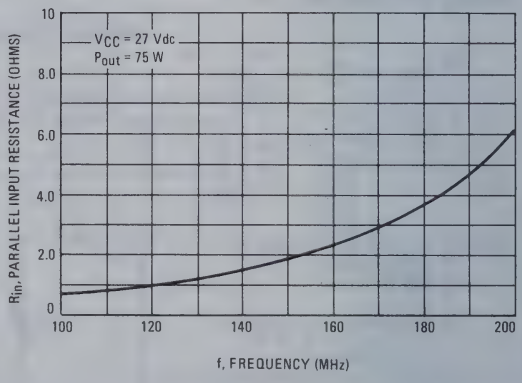


FIGURE 7 – V_{CC} = 27 Vdc, P_{out} = 75 W



PARALLEL INPUT CAPACITANCE versus FREQUENCY

FIGURE 8 – V_{CC} = 13.5 Vdc, P_{out} = 25 W

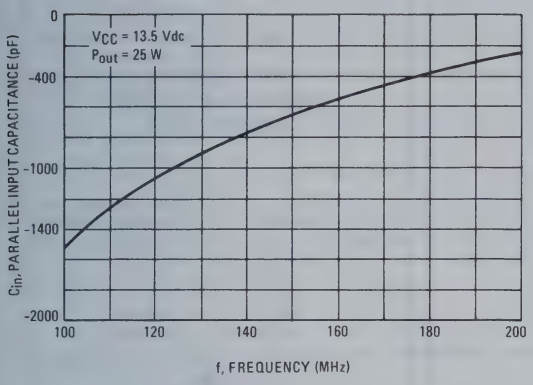
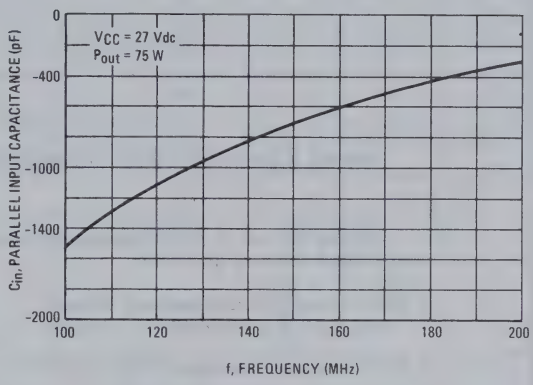


FIGURE 9 – V_{CC} = 27 Vdc, P_{out} = 75 W



PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10 – V_{CC} = 13.5 Vdc, P_{out} = 25 W

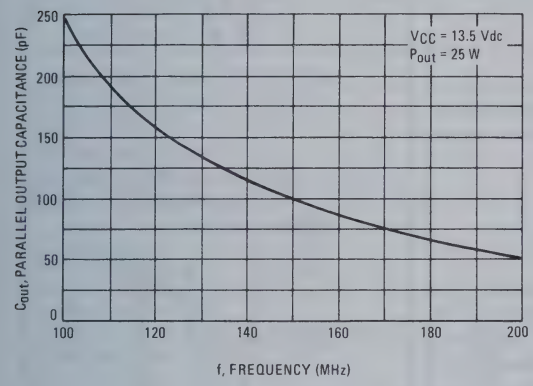


FIGURE 11 – V_{CC} = 27 Vdc, P_{out} = 75 W

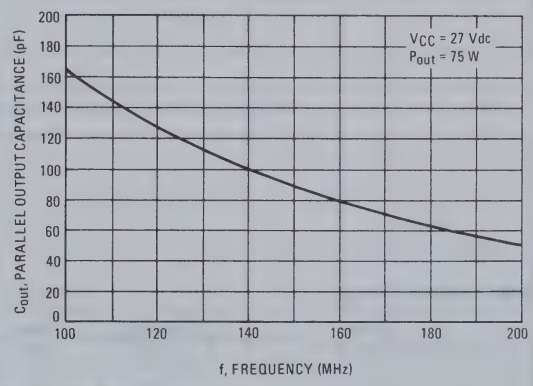
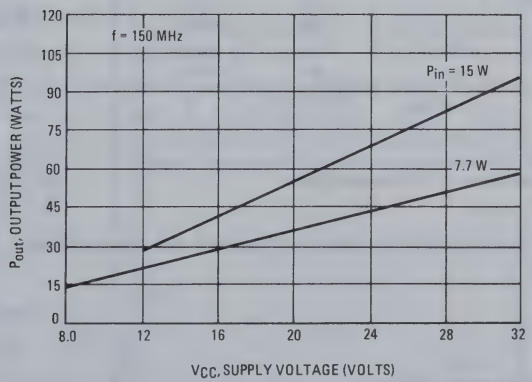


FIGURE 12 – OUTPUT POWER versus SUPPLY VOLTAGE



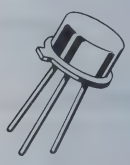
2N5864 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose amplifier and medium-speed switching applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 70 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain Specified — 50 mA to 500 mA
- High Collector Current — I_C = 1.5 Adc

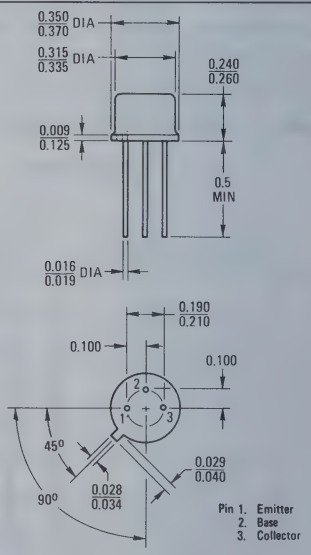
PNP SILICON GENERAL-PURPOSE TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	70	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation@T_C = 25°C Derate above 25°C	P_D**	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data
**Motorola Guarantees this data in addition to JEDEC Registered Data.



All JEDEC dimensions and notes apply
Collector connected to case

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	70	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	90	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	–	0.5	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	–	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		50	500	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		35	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		25	–	
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$		0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$**	–	1.25	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	25	pF
Emitter-Base Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)	C_{eb}**	–	150	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	200	1500	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	5.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	500	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	10	200	μmhos

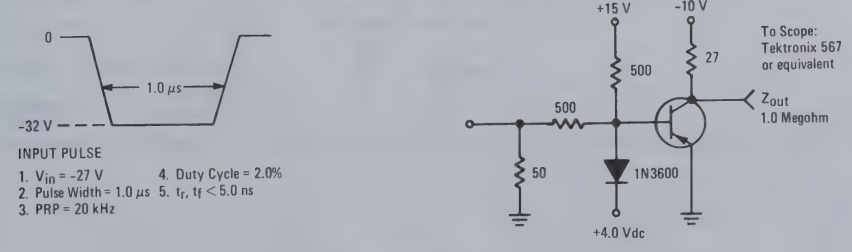
SWITCHING CHARACTERISTICS (See Figure 1)**

Delay Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_d	–	30	ns
Rise Time		t_r	–	100	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc)	t_s	–	500	ns
Fall Time		t_f	–	250	ns

*Indicates JEDEC Registered Data. **Motorola guarantees this data in addition to JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



2N5865 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed where high-current, high-voltage conditions are requirements for general-purpose switching and amplifier applications.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain Specified – 1.0 mA to 500 mA
- Turn-On Time –
  t_{on} = 120 ns (Max) @ I_C = 500 mAdc

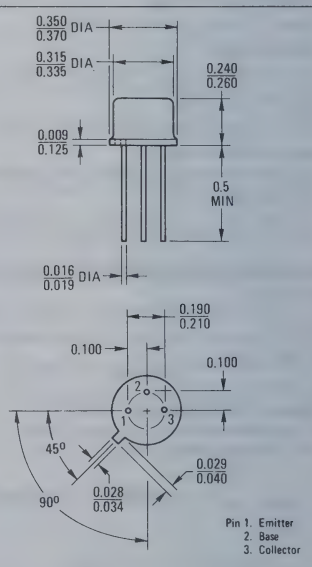
PNP SILICON GENERAL-PURPOSE TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



Pin 1. Emitter
2. Base
3. Collector

All JEDEC dimensions and notes apply

CASE 79-02
TO-39

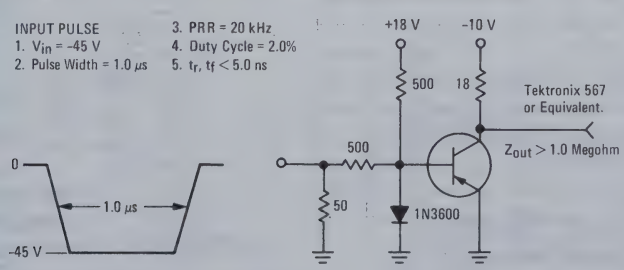
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	70	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	–	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	200	nAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		40	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		40	200	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		20	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	1.25	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	100	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	20	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	150	pF
SWITCHING CHARACTERISTICS				
Delay Time; (V_{CC} = 10 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	–	30	ns
Rise Time; (V_{CC} = 10 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_r	–	90	ns
Storage Time; (V_{CC} = 10 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	–	350	ns
Fall Time; (V_{CC} = 10 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_f	–	150	ns

*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates itself to unity.

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



2N5867, 2N5868 PNP (SILICON)
2N5869, 2N5870 NPN

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

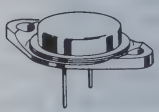
. . .designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 2.0 Adc
- Low Leakage Current — I_{CEX} = 0.1 mAdc (Max)
- Excellent DC Current Gain — h_{FE} = 20 (Min) @ I_C = 1.5 Adc
- High Current Gain — Bandwidth Product — f_T = 4.0 MHz at I_C = 0.25 Adc

5.0 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS
87.5 WATTS



*MAXIMUM RATINGS

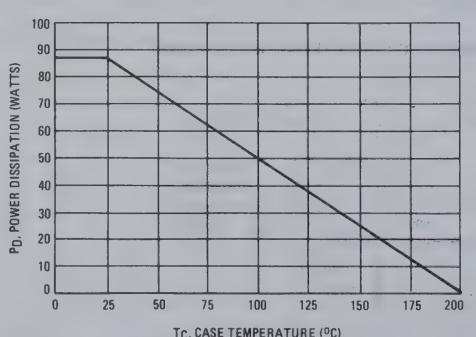
Rating	Symbol	2N5867 2N5869	2N5868 2N5870	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 0.5		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

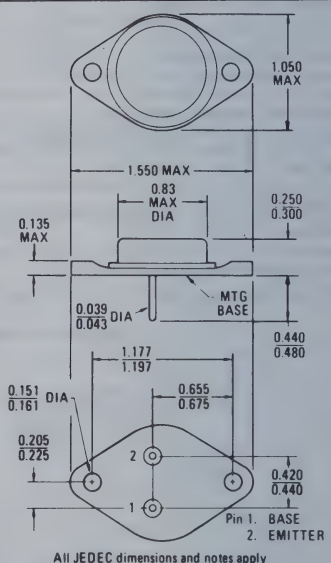
THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

*Indicates JEDEC registered data. Limits and conditions differ on some parameters and registration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.

FIGURE 1 — POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

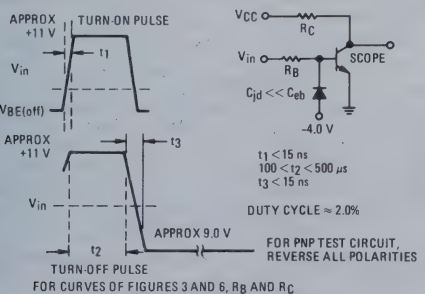
CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N5867, 2N5869		60	–	
	2N5868, 2N5870		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5867, 2N5869		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N5868, 2N5870		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5867, 2N5869		–	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5868, 2N5870		–	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5867, 2N5869		–	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5868, 2N5870		–	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5867, 2N5869		–	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N5868, 2N5870		–	0.1	
Emitter Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{EB} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 0.3 Adc, V_{CE} = 4.0 Vdc)			35	–	
(I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	1.0	
(I_C = 5.0 Adc, I_B = 1.25 Adc)			–	2.0	
Base-Emitter On Voltage (1)		$V_{BE(on)}$	–	1.5	Vdc
(I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)					
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$	–	2.5	Vdc
(I_C = 5.0 Adc, I_B = 1.25 Adc)					
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (2)		f_T	4.0	–	MHz
(I_C = 0.25 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)					
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5867, 2N5868		–	200	
	2N5869, 2N5870		–	150	
Small-Signal Current Gain		h_{fe}	20	–	–
(I_C = 0.25 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)					
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 1.5 Adc, I_{B1} = I_{B2} = 0.15 Adc)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 AND 6, R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FIGURE 3 – TURN "ON" TIME

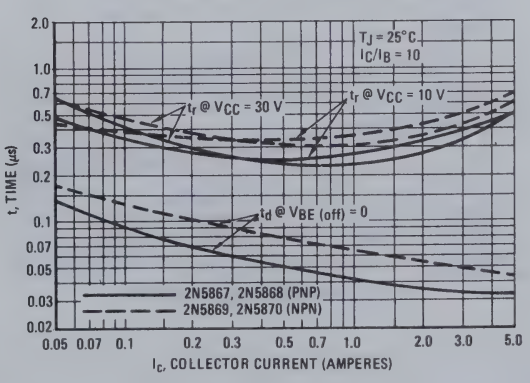


FIGURE 4 – THERMAL RESPONSE

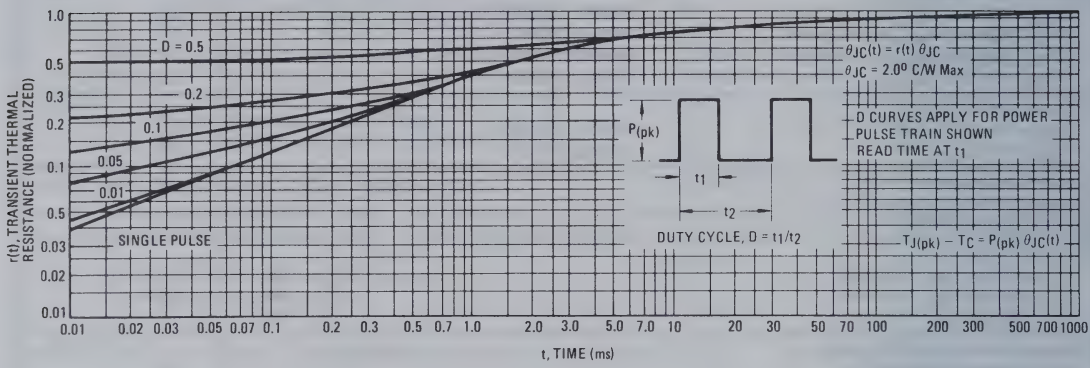
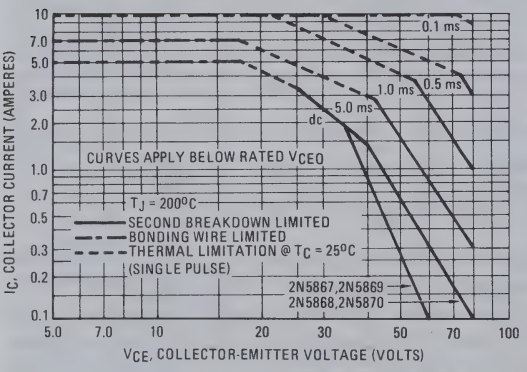


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415).

FIGURE 6 – TURN "OFF" TIME

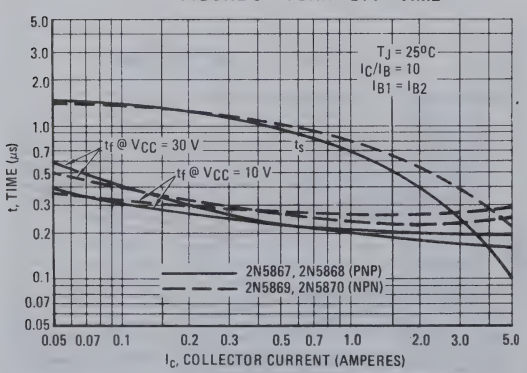
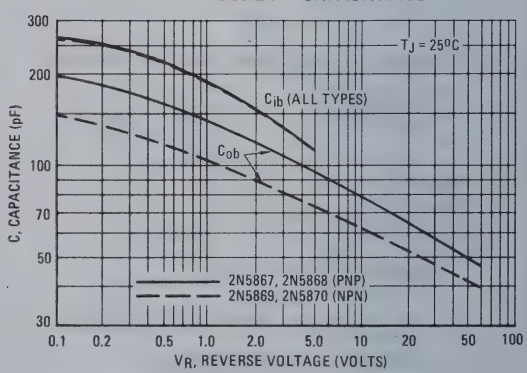


FIGURE 7 – CAPACITANCE



PNP
2N5867 and 2N5868

NPN
2N5869 and 2N5870

FIGURE 8 – DC CURRENT GAIN

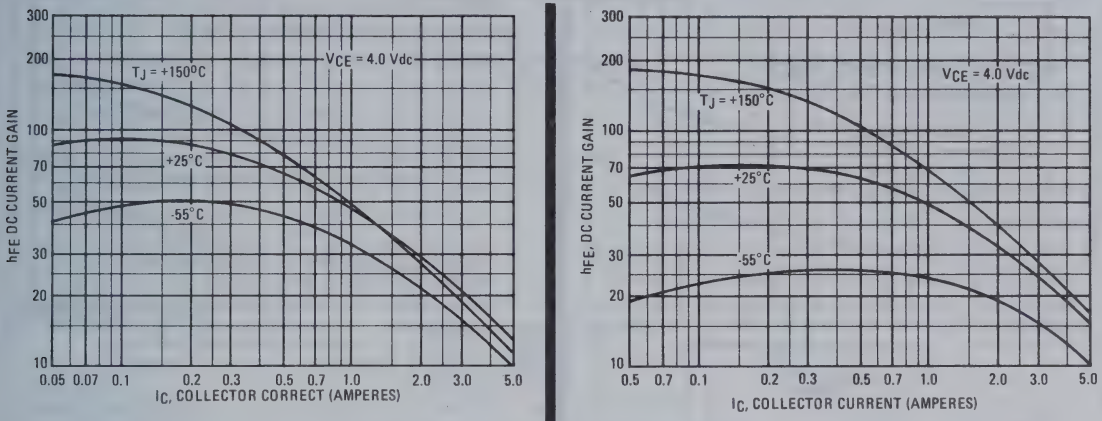


FIGURE 9 – COLLECTOR SATURATION REGION

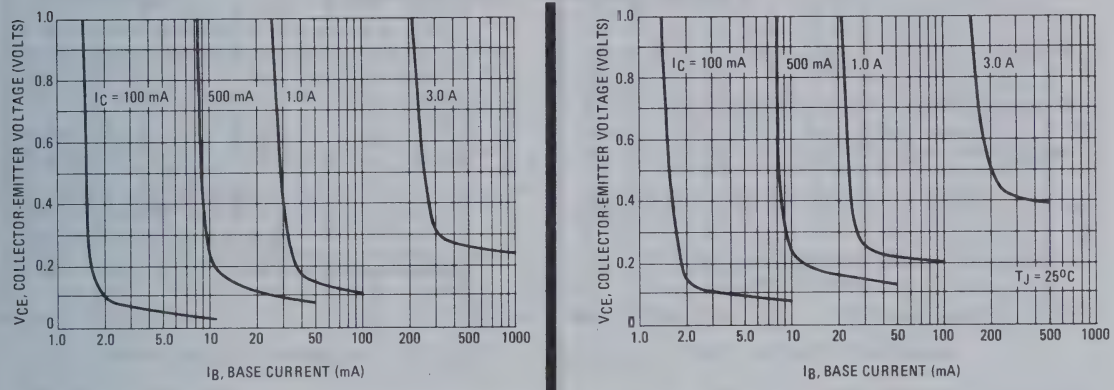
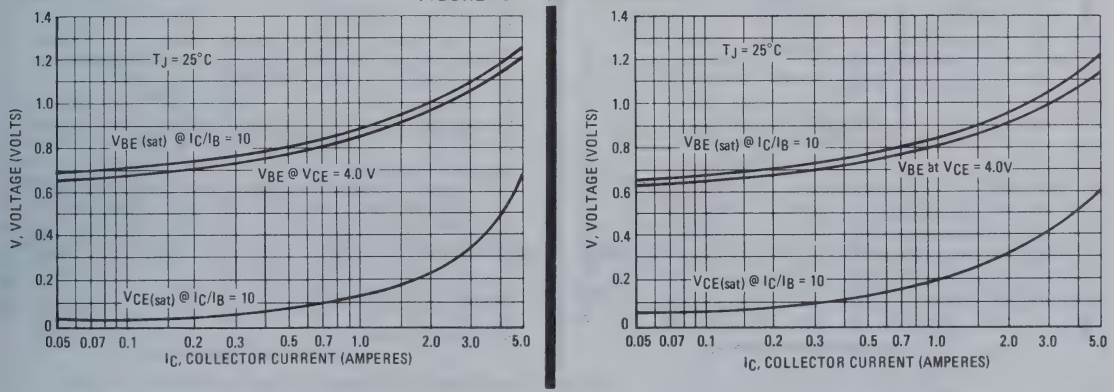


FIGURE 10 – "ON" VOLTAGES



PNP
2N5867 and 2N5868

NPN
2N5869 and 2N5870

FIGURE 11 – TEMPERATURE COEFFICIENTS

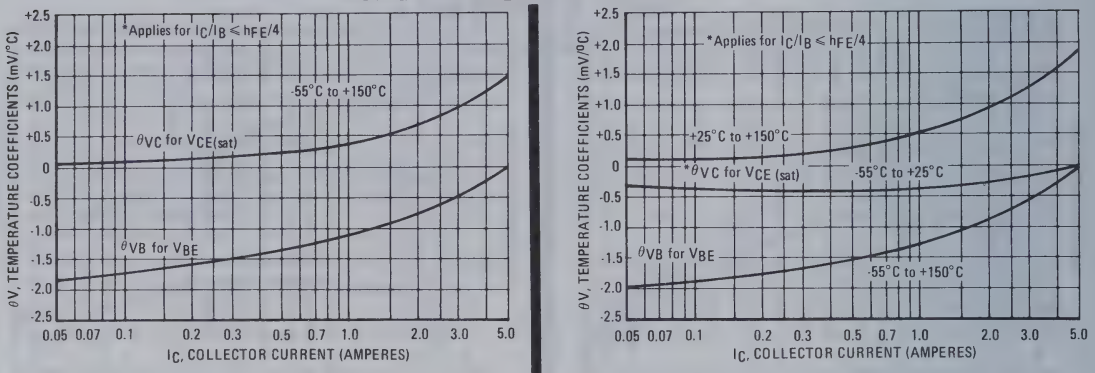


FIGURE 12 – COLLECTOR CUT-OFF REGION

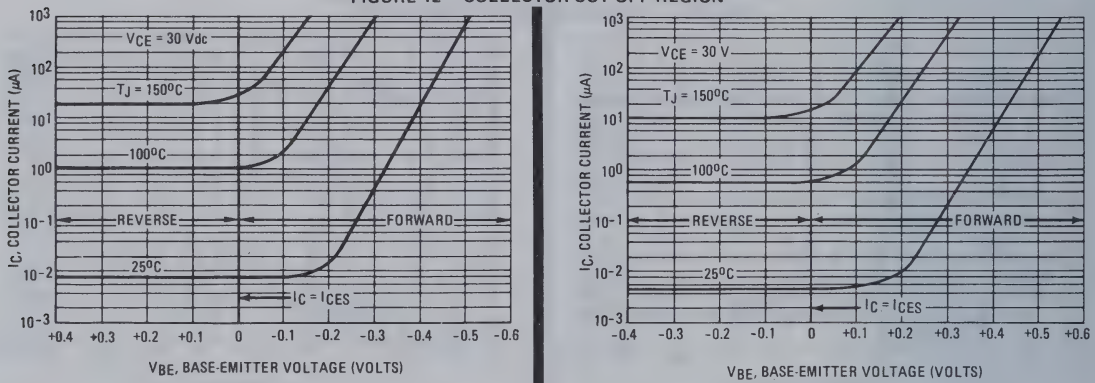
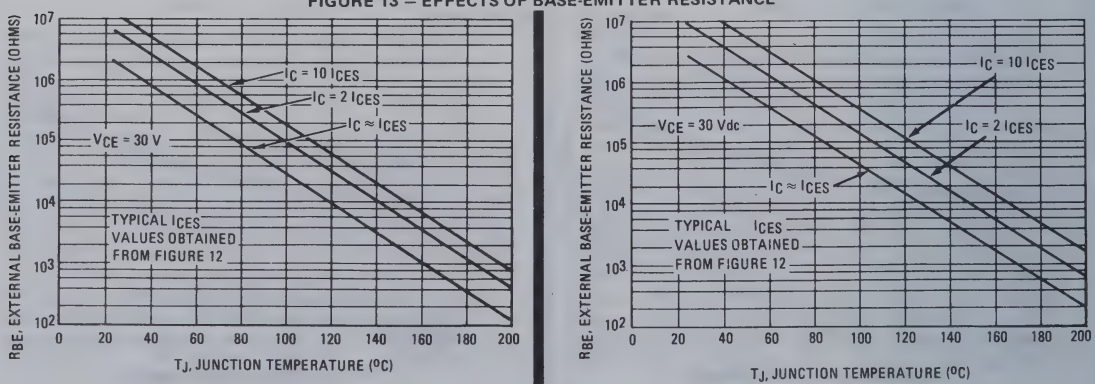


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5871, 2N5872, 2N6317, 2N6318 PNP (SILICON)
2N5873, 2N5874, 2N6315, 2N6316 NPN

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 4.0 Adc
- Low Leakage Current — I_{CEX} = 0.25 mAdc (Max)
- Excellent DC Current Gain — h_{FE} = 20 (Min) @ I_C = 2.5 Adc
- High Current Gain — Bandwidth Product — f_T = 4.0 MHz @ I_C = 0.25 Adc
- Choice of Packages — TO-3 — 2N5871/2N5874
  TO-66 — 2N6315/2N6318

7.0 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

60–80 VOLTS

115 WATTS — TO-3
90 WATTS — TO-66

*MAXIMUM RATINGS

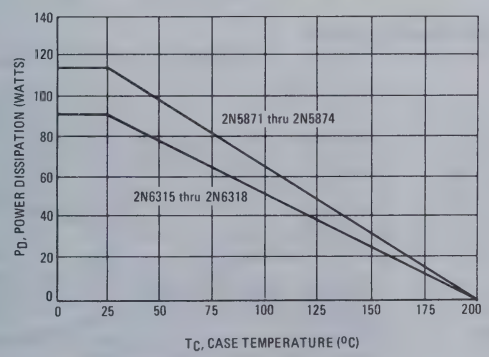
Rating	Symbol	2N5871 2N5873 2N6315 2N6317	2N5872 2N5874 2N6316 2N6318	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	7.0 15		Adc
Base Current	I_B	2.0		Adc
		2N5871 Series	2N6315 Series	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.658	90 0.515	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N5871 2N5872 2N5873 2N5874	2N6315 2N6316 2N6317 2N6318	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	1.94	°C/W

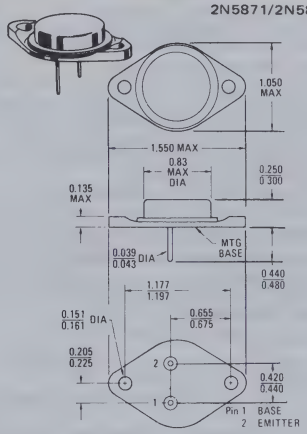
*Indicates JEDEC registered data. Limits and conditions differ on some parameters and re-registration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.

FIGURE 1 — POWER DERATING



Safe Area Limits are indicated by Figures 5 and 6. Both limits are applicable and must be observed.

2N5871/2N5874

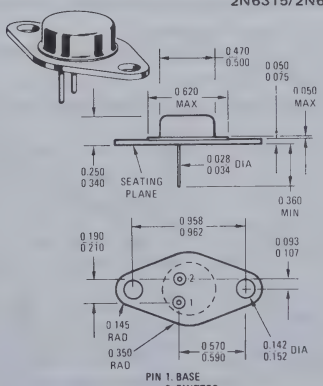


All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

2N6315/2N6318



All JEDEC dimensions and notes apply

Collector connected to case

CASE 80-02
TO-66

2N5871, 2N5872, 2N6317, 2N6318 PNP (continued)
2N5873, 2N5874, 2N6315, 2N6316 NPN

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N5871,2N5873,2N6315,2N6317		60	–	
	2N6872,2N5874,2N6316,2N6318		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5871,2N5873,2N6315,2N6317		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N5872,2N5874,2N6316,2N6318		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5871,2N5873,2N6315,2N6317		–	0.25	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5872,2N5874,2N6316,2N6318		–	0.25	
(V_{CE} = 60 Vdc $V_{BE(off)}$ =1.5 Vdc,T_C =150°C)	2N5871,2N5873,2N6315,2N6317		–	2.0	
(V_{CE} = 80 Vdc,$V_{BE(off)}$ =1.5 Vdc,T_C =150°C)	2N5872,2N5874,2N6316,2N6318		–	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5871,2N5873,2N6315,2N6317		–	0.25	
(V_{CB} = 80 Vdc, I_E = 0)	2N5872,2N5874,2N6316,2N6318		–	0.25	
Emitter Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{EB} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc)			35	–	
(I_C = 2.5 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 7.0 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 0.4 Adc)			–	1.0	
(I_C = 7.0 Adc, I_B = 1.75 Adc)			–	2.0	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$	–	2.5	Vdc
(I_C = 7.0 Adc, I_B = 1.75 Adc)					
Base-Emitter On Voltage (1)		$V_{BE(on)}$	–	1.5	Vdc
(I_C = 2.5 Adc, V_{CE} = 4.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T	4.0	–	MHz
(I_C = 0.25 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)					
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5871,2N5872,2N6317,2N6318		–	300	
	2N5873,2N5874,2N6315,2N6316		–	200	
Small-Signal Current Gain		h_{fe}	20	–	–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)					
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 2.5 Adc, I_{B1} = I_{B2} = 0.25 Adc)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

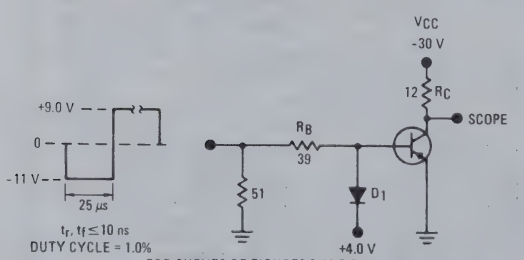
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

TYPICAL CHARACTERISTICS

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 AND 7, R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS.

D_1 MUST BE FAST RECOVERY TYPE, e.g.

MBD5300 USED ABOVE $I_B \approx 100$ mA

MSD6100 USED BELOW $I_B \approx 100$ mA

FOR NPN TEST CIRCUIT, REVERSE ALL POLARITIES.

FIGURE 3 – TURN "ON" TIME

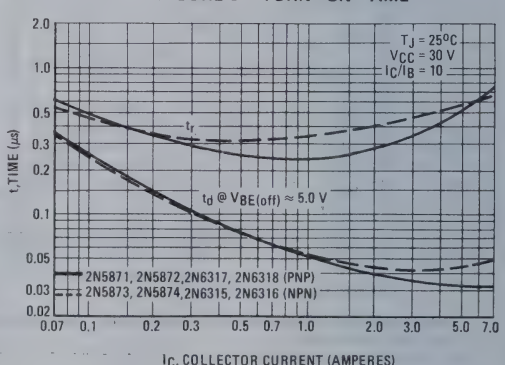
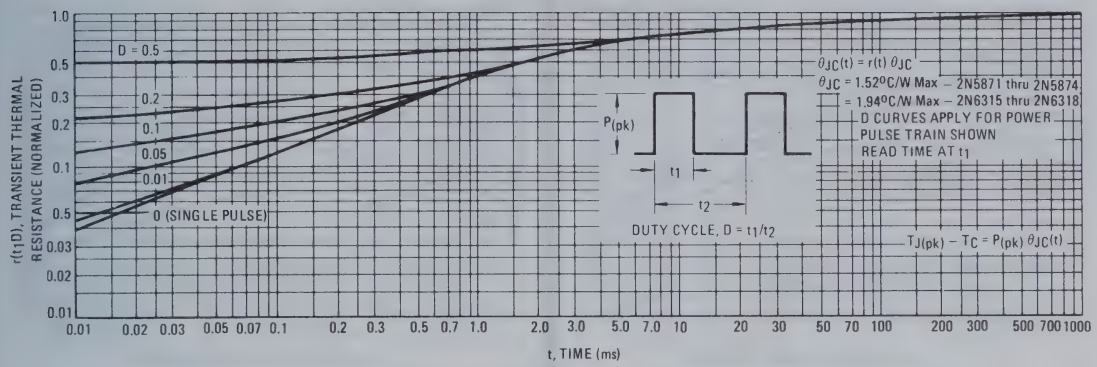


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – 2N5871 thru 2N5874

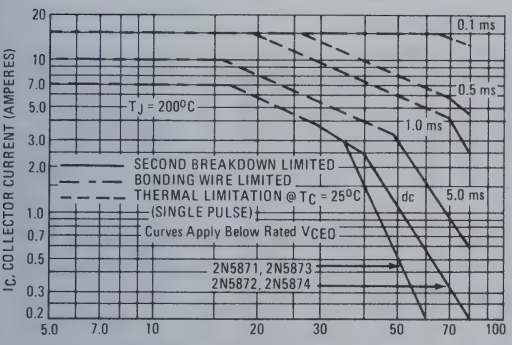
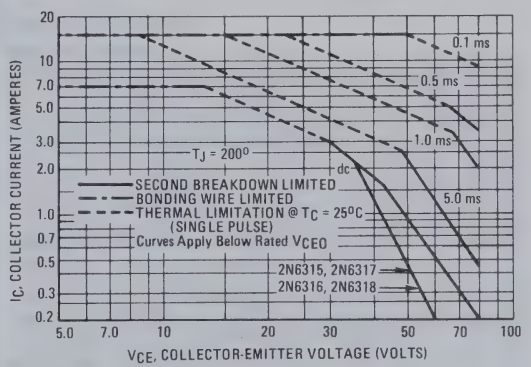


FIGURE 6 – 2N6315 thru 2N6318



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitaitons imposed by second breakdown.

FIGURE 7 – TURN "OFF" TIME

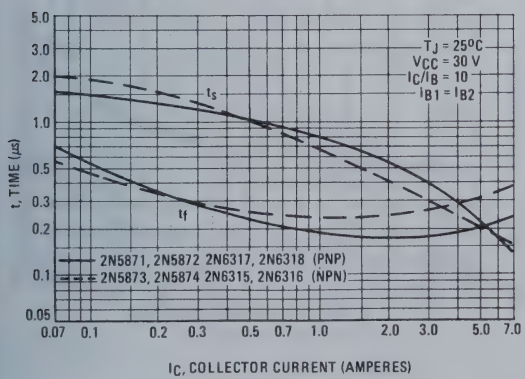


FIGURE 8 – CAPACITANCE

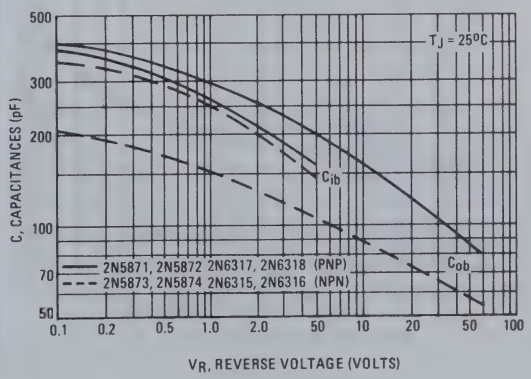


FIGURE 9 – DC CURRENT GAIN

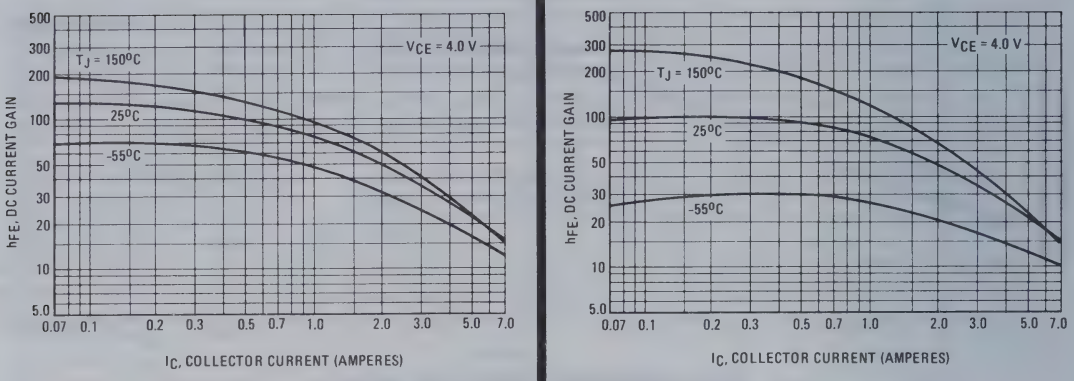


FIGURE 10 – COLLECTOR SATURATION REGION

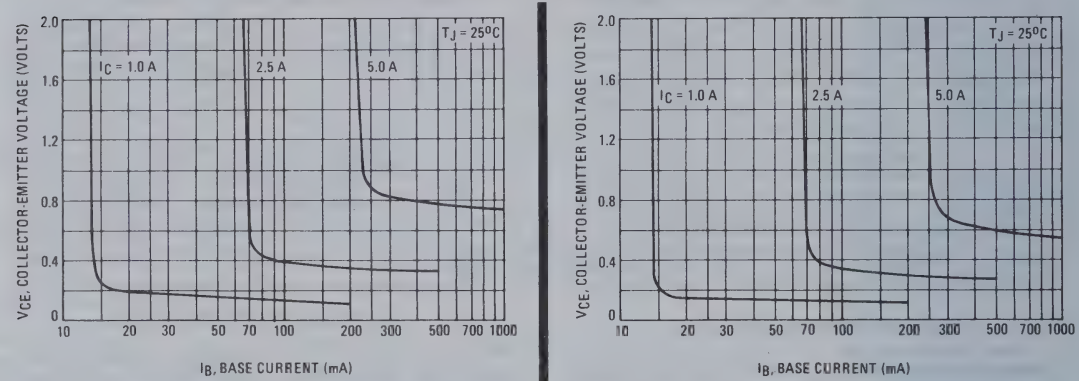
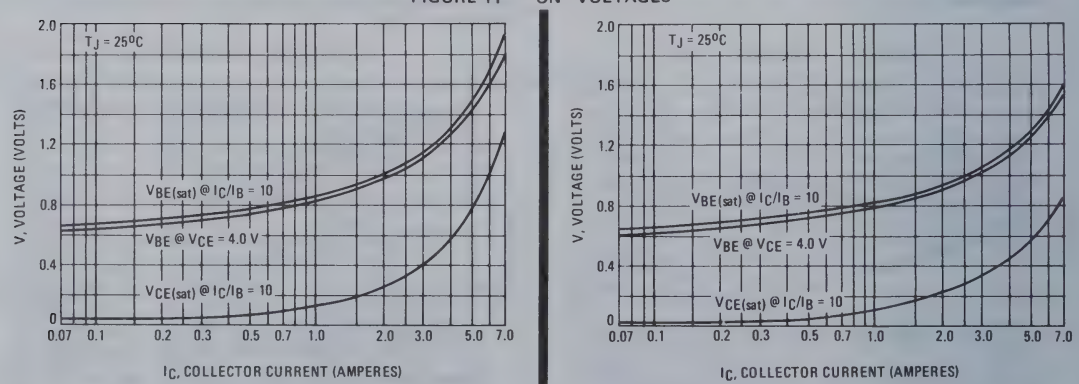


FIGURE 11 – "ON" VOLTAGES



PNP
2N5871 and 2N5872
2N6317 and 2N6318

NPN
2N5873 and 2N5874
2N6315 and 2N6316

FIGURE 12 – TEMPERATURE COEFFICIENTS

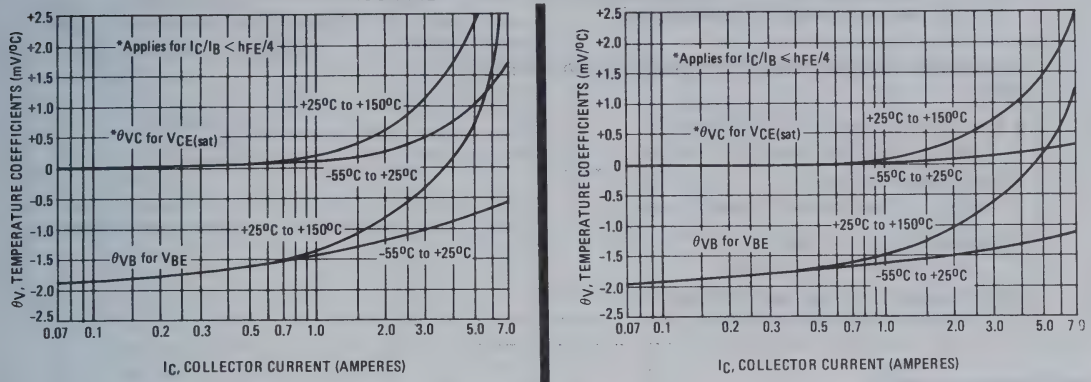


FIGURE 13 – COLLECTOR CUT-OFF REGION

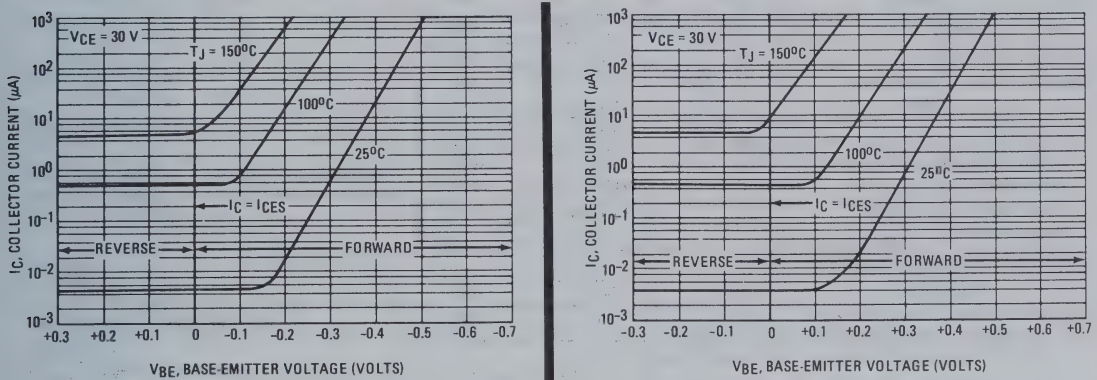
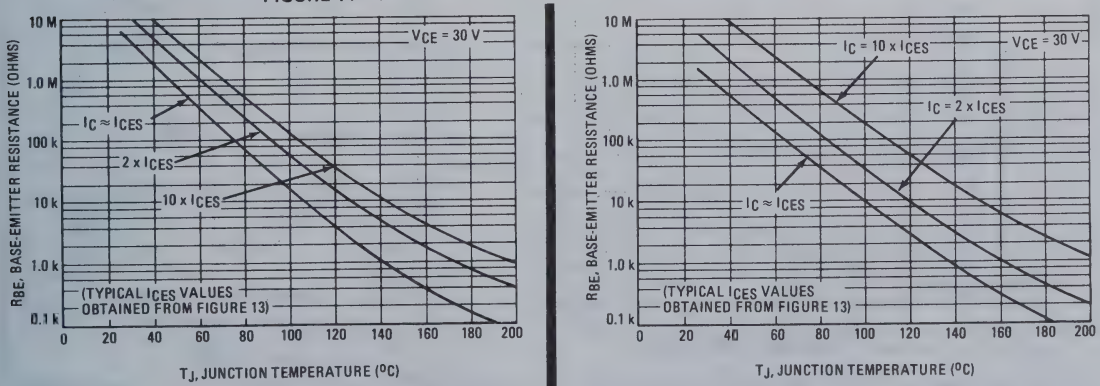


FIGURE 14 – EFFECTS OF EXTERNAL BASE-EMITTER RESISTANCE



2N5875, 2N5876 PNP (SILICON)
2N5877, 2N5878 NPN

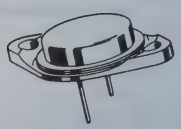
COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 5.0 Adc
- Low Leakage Current –
  I_{CEX} = 0.5 mAdc (Max) @ Rated Voltage
- Excellent DC Current Gain –
  h_{FE} = 20 (Min) @ I_C = 4.0 Adc
- High Current Gain – Bandwidth Product –
  f_T = 4.0 MHz (Min) @ I_C = 0.5 A

10 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60-80 VOLTS
150 WATTS



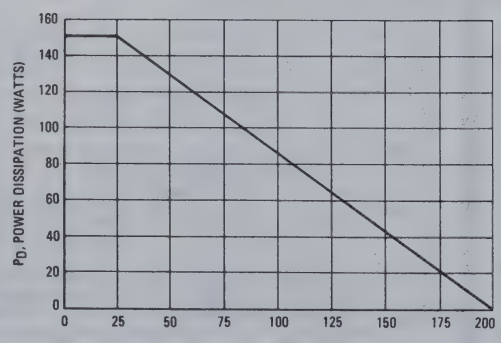
*MAXIMUM RATINGS

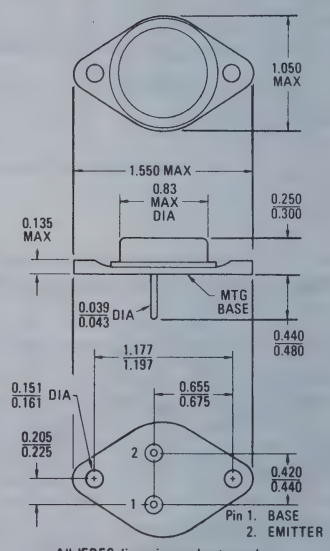
Rating	Symbol	2N5875 2N5877	2N5876 2N5878	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	10 20		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.857		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

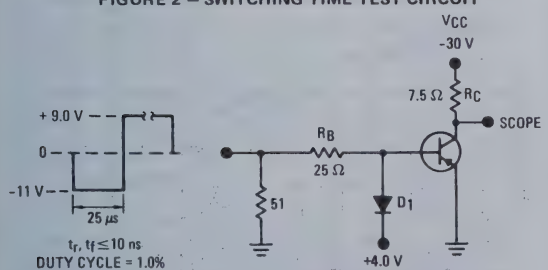
CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5875, 2N5877		60	–	
	2N5876, 2N5878		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5875, 2N5877		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5876, 2N5878		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5875, 2N5877		–	0.5	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5876, 2N5878		–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5875, 2N5877		–	5.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5876, 2N5878		–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5875, 2N5877		–	0.5	
(V_{CB} = 80 Vdc, I_E = 0)	2N5876, 2N5878		–	0.5	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_E = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			35	–	
(I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)			–	1.0	
(I_C = 10 Adc, I_B = 2.5 Adc)			–	3.0	
Base-Emitter Saturation Voltage (1) (I_C = 10 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance		C_{ob}	–		pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5875, 2N5876		–	500	
	2N5877, 2N5878		–	300	
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 4.0 Adc, I_{B1} = I_{B2} = 0.4 Adc, See Figure 2)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 and 6, R_B and R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

For NPN test circuit, reverse all polarities.

D_1 MUST BE FAST RECOVERY TYPE, e.g.
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

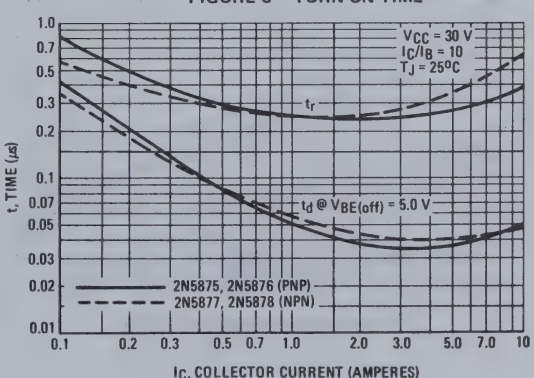


FIGURE 4 – THERMAL RESPONSE

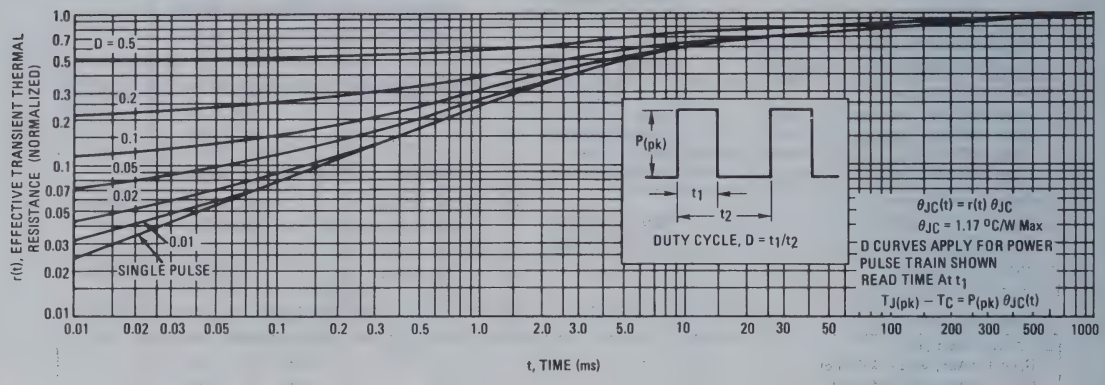
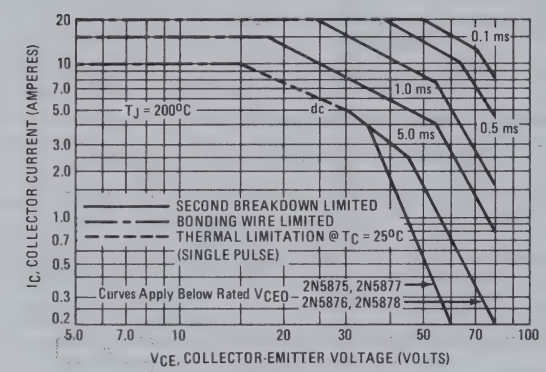


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

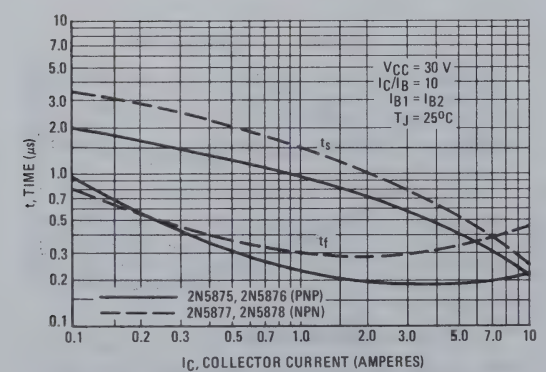
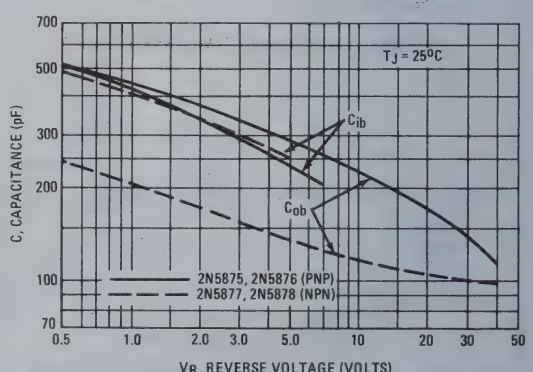


FIGURE 7 – CAPACITANCE



PNP DEVICES
2N5875 and 2N5876

NPN DEVICES
2N5877 and 2N5878

FIGURE 8 – DC CURRENT GAIN

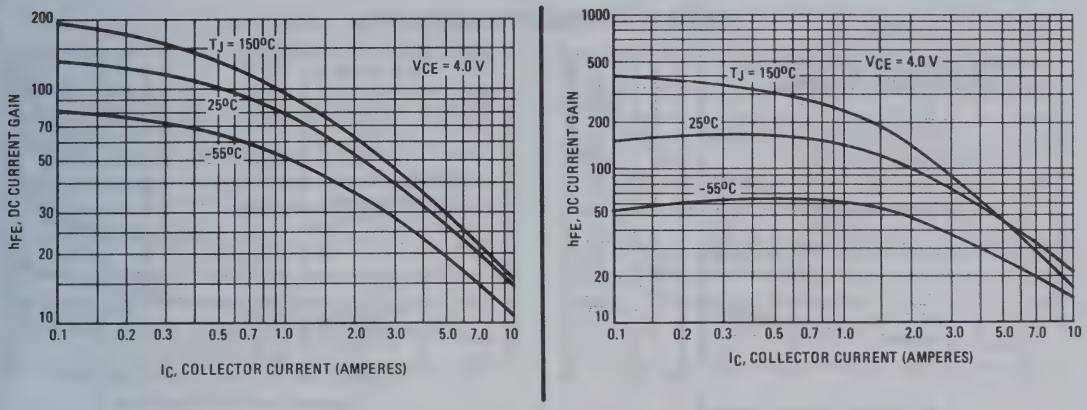


FIGURE 9 – COLLECTOR SATURATION REGION

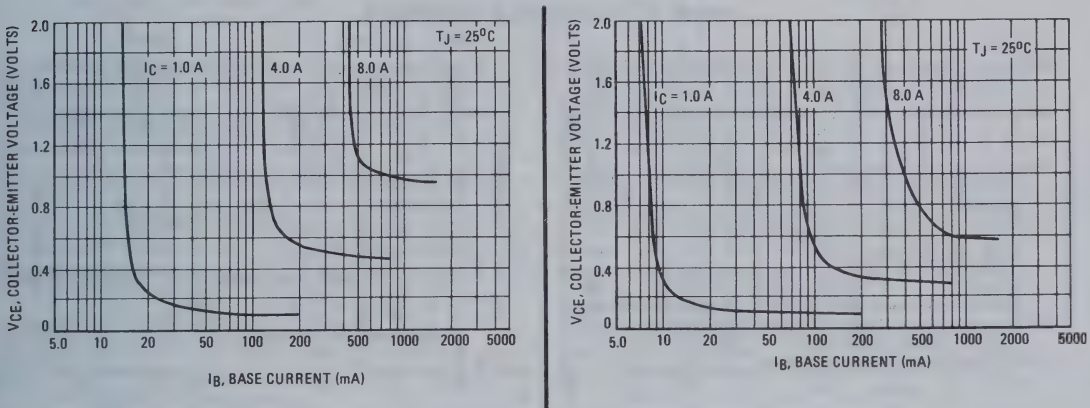
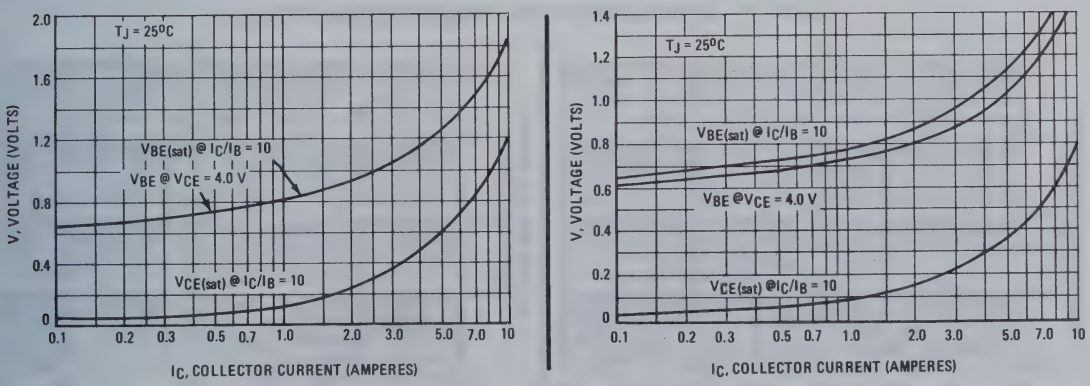


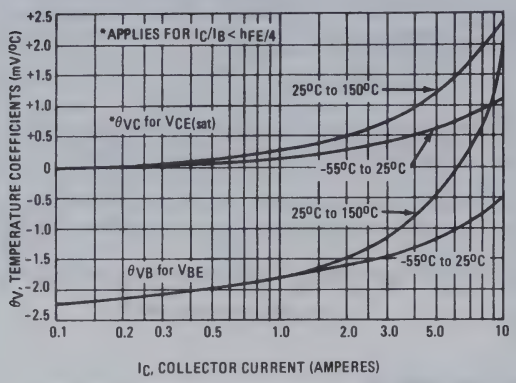
FIGURE 10 – "ON" VOLTAGES



PNP DEVICES
2N5875 and 2N5876

NPN DEVICES
2N5877 and 2N5878

FIGURE 11 – TEMPERATURE COEFFICIENTS



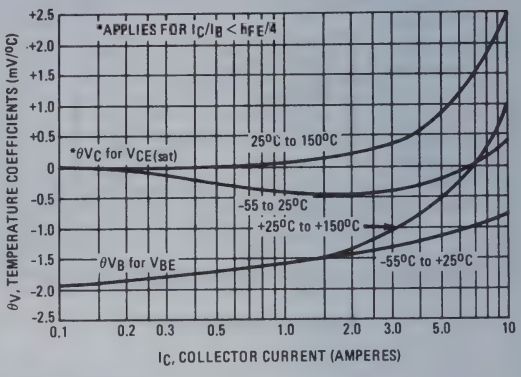
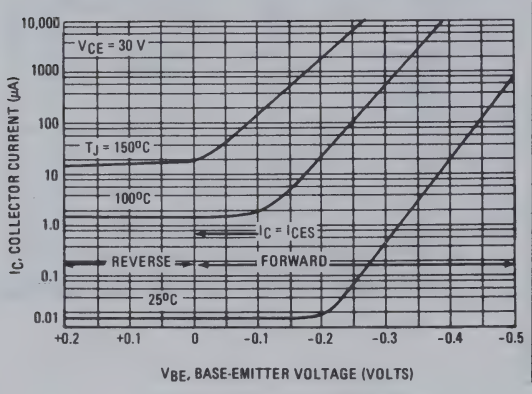


FIGURE 12 – COLLECTOR CUT-OFF REGION



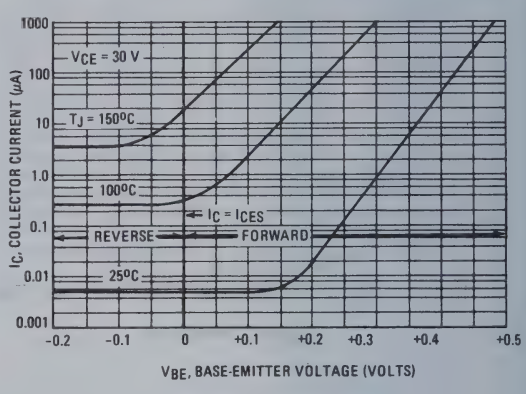
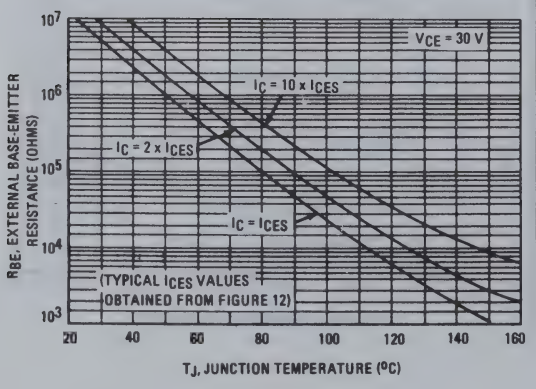
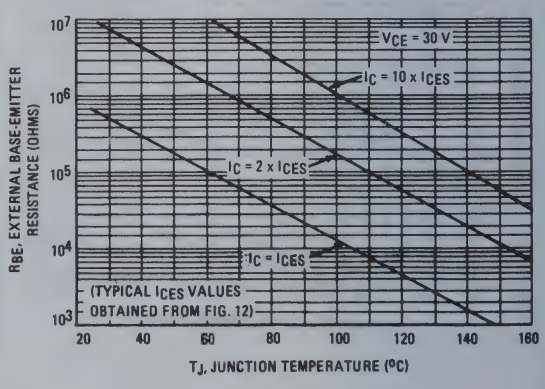


FIGURE 13 – EFFECTS OF EXTERNAL BASE-EMITTER RESISTANCE





2N5879, 2N5880 PNP (SILICON)
2N5881, 2N5882 NPN

COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 60 Vdc (Min) – 2N5879, 2N5881
  = 80 Vdc (Min) – 2N5880, 2N5882
- DC Current Gain –
  h_{FE} = 20 (Min) @ I_C = 6.0 Adc
- Low Collector – Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 7.0 Adc
- High Current – Gain-Bandwidth Product –
  f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- Recommended for New Circuit Designs

15 AMPERE
COMPLEMENTARY SILICON POWER TRANSISTORS
60–80 VOLTS
160 WATTS



*MAXIMUM RATINGS

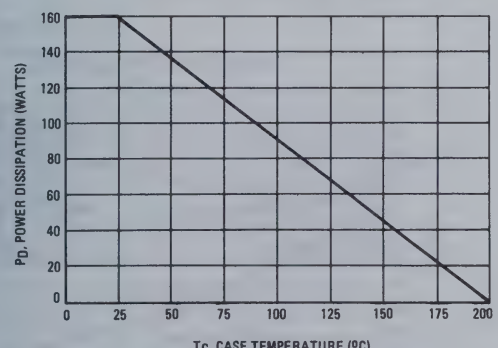
Rating	Symbol	2N5879 2N5881	2N5880 2N5882	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	15 30		Adc
Base Current	I_B	5.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	160 0.915		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

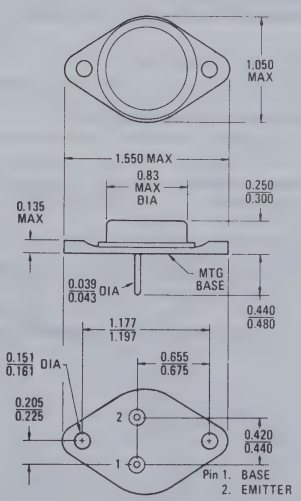
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.1	°C/W

*Indicates JEDEC registered data. Limits and conditions differ on some parameters and re-registration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.

FIGURE 1 – POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

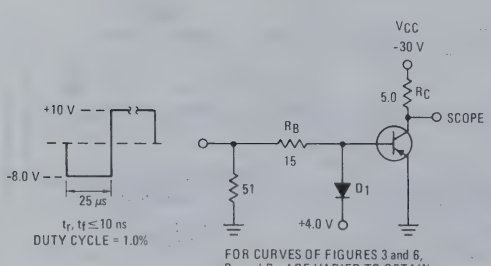
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	2N5879, 2N5881	$V_{CEO(sus)}$	60	–	Vdc
	2N5880, 2N5882		80	–	
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	2N5879, 2N5881	I_{CEO}	–	1.0	mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5880, 2N5882		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5879, 2N5881		–	0.5	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5880, 2N5882		–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5879, 2N5881		–	5.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5880, 2N5882		–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5879, 2N5881		–	0.5	
(V_{CB} = 80 Vdc, I_E = 0)	2N5880, 2N5882		–	0.5	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 4.0 Vdc)			35	–	
(I_C = 6.0 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)			–	1.0	
(I_C = 15 Adc, I_B = 3.75 Adc)			–	4.0	
Base-Emitter Saturation Voltage (1) (I_C = 15 Adc, I_B = 3.75 Adc)		$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage (1) (I_C = 6.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N5879, 2N5880		–	600	
	2N5881, 2N5882		–	400	
Small-Signal Current Gain (I_C = 2.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 6.0 Adc, I_{B1} = I_{B2} = 0.6 Adc See Figure 2)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



FOR CURVES OF FIGURES 3 and 6, R_B and R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:

MBD5300 USED ABOVE I_B ≈ 100 mA

MSD6100 USED BELOW I_B ≈ 100 mA

For NPN test circuit, reverse all polarities.

FIGURE 3 – TURN-ON TIME

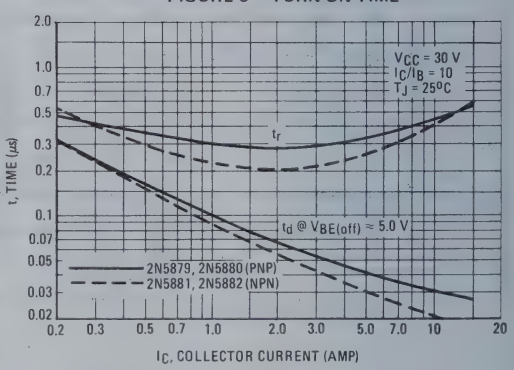


FIGURE 4 – THERMAL RESPONSE

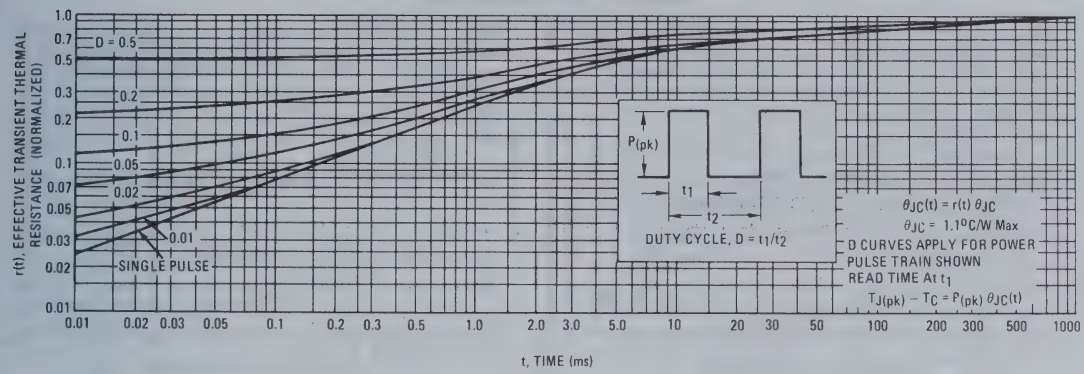
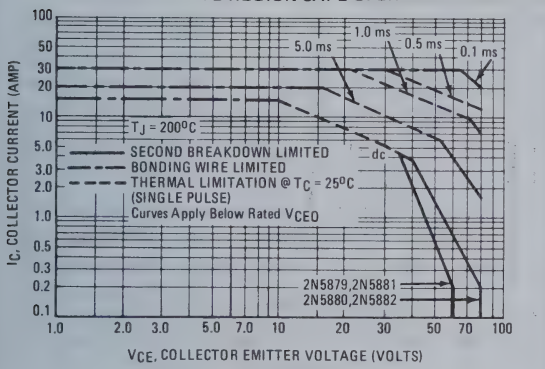


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

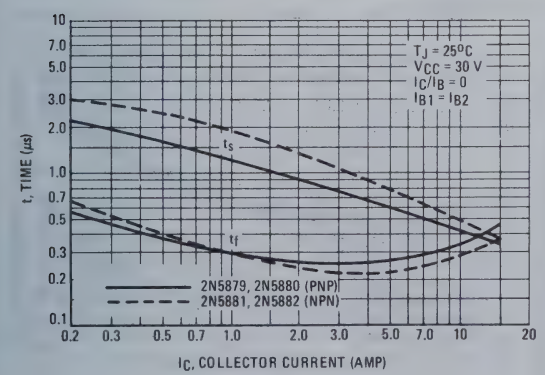
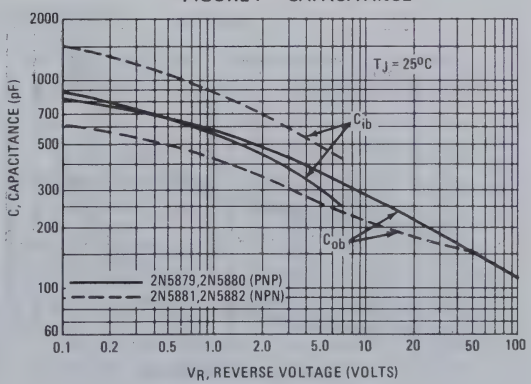


FIGURE 7 – CAPACITANCE



PNP
2N5879, 2N5880

NPN
2N5881, 2N5882

FIGURE 8 – DC CURRENT GAIN

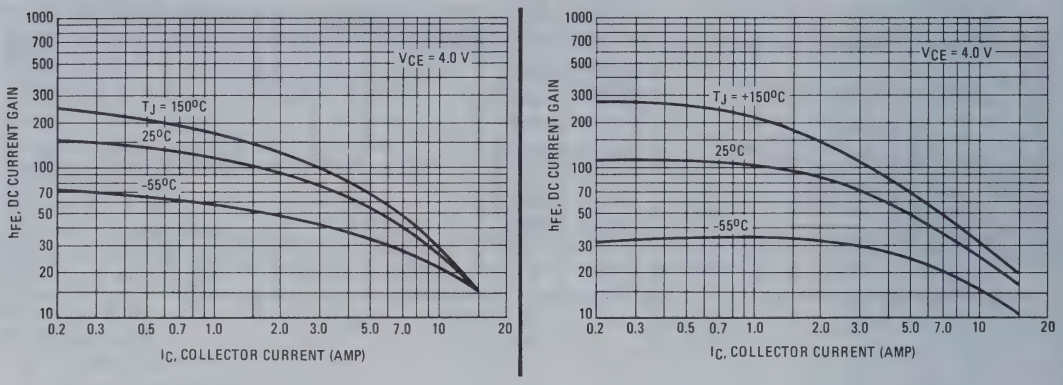


FIGURE 9 – COLLECTOR SATURATION REGION

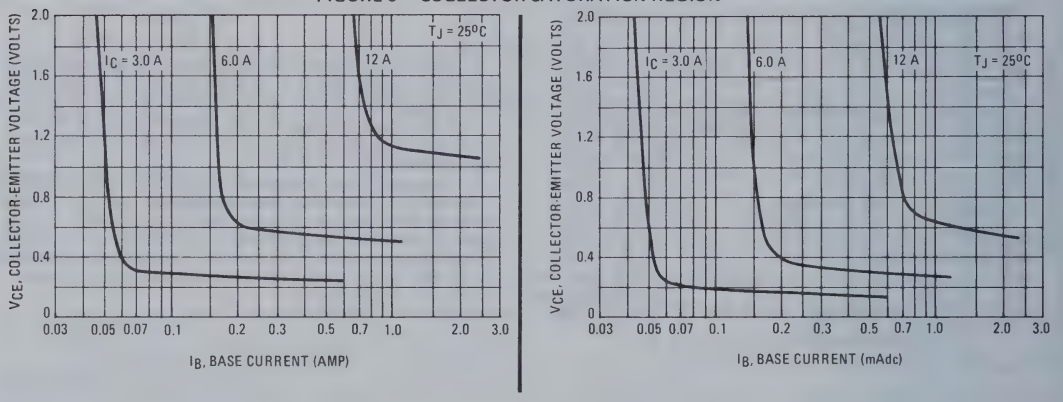
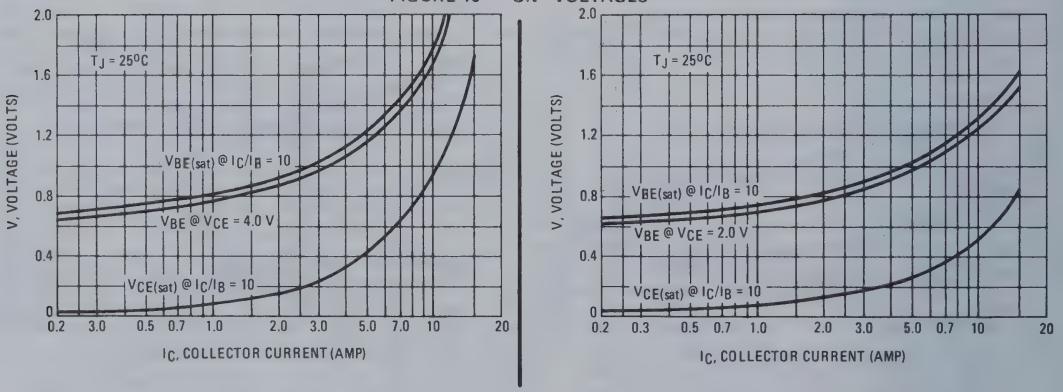


FIGURE 10 – "ON" VOLTAGES



PNP
2N5879, 2N5880

NPN
2N5881, 2N5882

FIGURE 11 – TEMPERATURE COEFFICIENTS

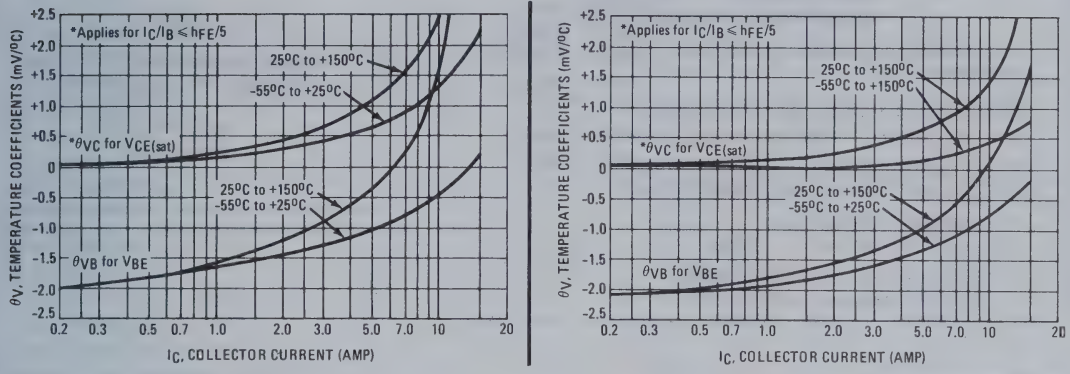


FIGURE 12 – COLLECTOR CUTOFF REGION

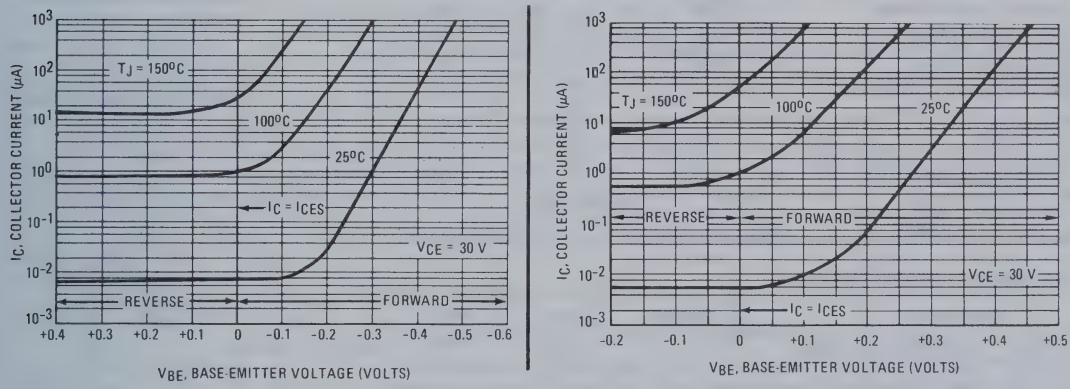
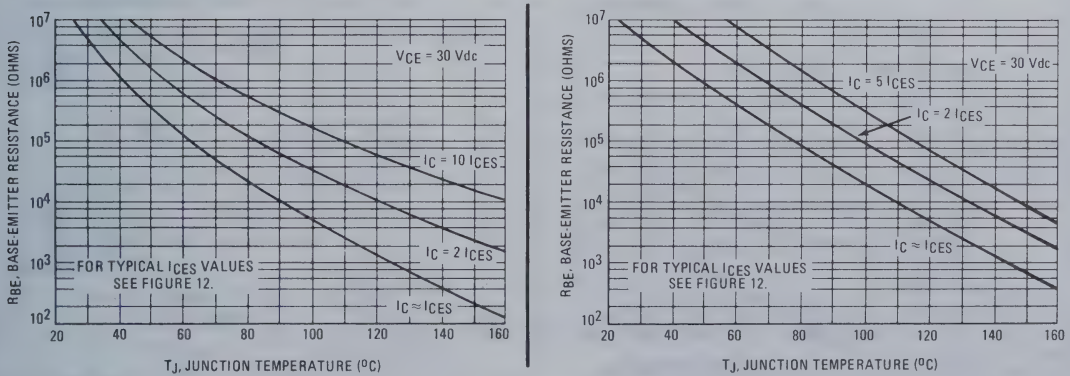


FIGURE 13 – EFFECTS OF EXTERNAL BASE-EMITTER RESISTANCE



2N5883, 2N5884 PNP (SILICON)
2N5885, 2N5886 NPN

COMPLEMENTARY SILICON HIGH-POWER TRANSISTORS

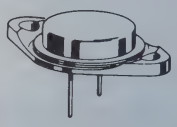
. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc, (max) at I_C = 15 Adc
- Low Leakage Current I_{CEX} = 1.0 mAdc (max) at Rated Voltage
- Excellent DC Current Gain — h_{FE} = 20 (min) at I_C = 10 Adc
- High Current Gain Bandwidth Product — f_T = 4.0 MHz (min) at I_C = 1.0 Adc

25 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

60–80 VOLTS
200 WATTS



*MAXIMUM RATINGS

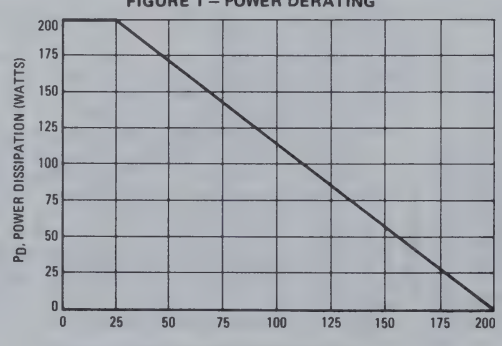
Rating	Symbol	2N5883 2N5885	2N5884 2N5886	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	25 50		Adc
Base Current	I_B	7.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.15		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

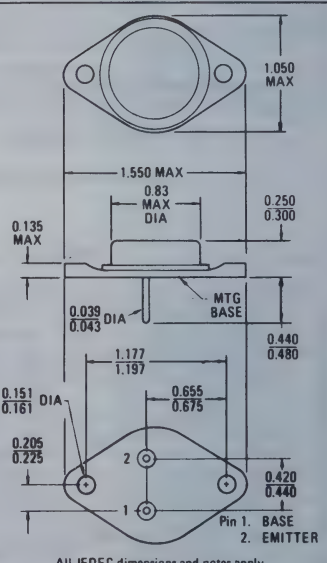
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

*Indicates JEDEC registered data. Limits and conditions differ on some parameters and re-registration reflecting these changes has been requested. All above values meet or exceed present JEDEC registered data.

FIGURE 1 — POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

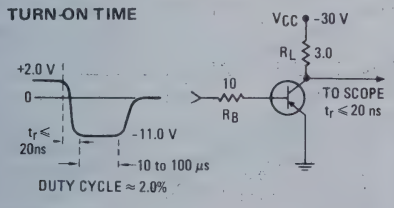
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	2N5883, 2N5885	$V_{CEO(sus)}$	60	–	Vdc
	2N5884, 2N5886		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5883, 2N5885		–	2.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5884, 2N5886		–	2.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5883, 2N5885		–	1.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5884, 2N5886		–	1.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5883, 2N5885		–	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5884, 2N5886		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5883, 2N5885		–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5884, 2N5886		–	1.0	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)			35	–	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 25 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 15 Adc, I_B = 1.5 Adc)			–	1.0	
(I_C = 25 Adc, I_B = 6.25 Adc)			–	4.0	
Base-Emitter Saturation Voltage (1) (I_C = 25 Adc, I_B = 6.25 Adc)		$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage (1) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5883, 2N5884		–	1000	
	2N5885, 2N5886		–	500	
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 1.0 kHz)		h_{fe}	20	–	–
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

*Indicates JEDEC Registered Data.

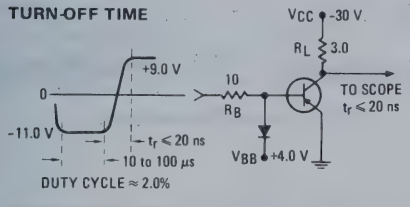
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%. (2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-ON TIME



TURN-OFF TIME



FOR CURVES OF FIGURES 3 & 6, R_B & R_L ARE VARIED.
INPUT LEVELS ARE APPROXIMATELY AS SHOWN.
FOR NPN, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

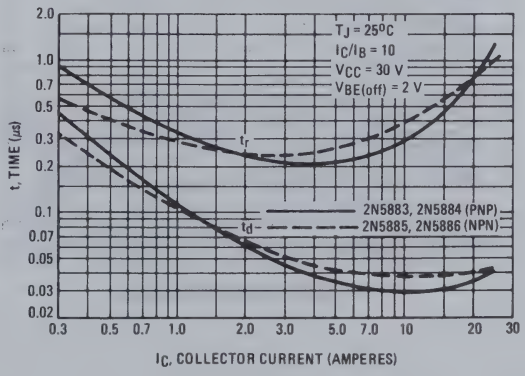


FIGURE 4 – THERMAL RESPONSE

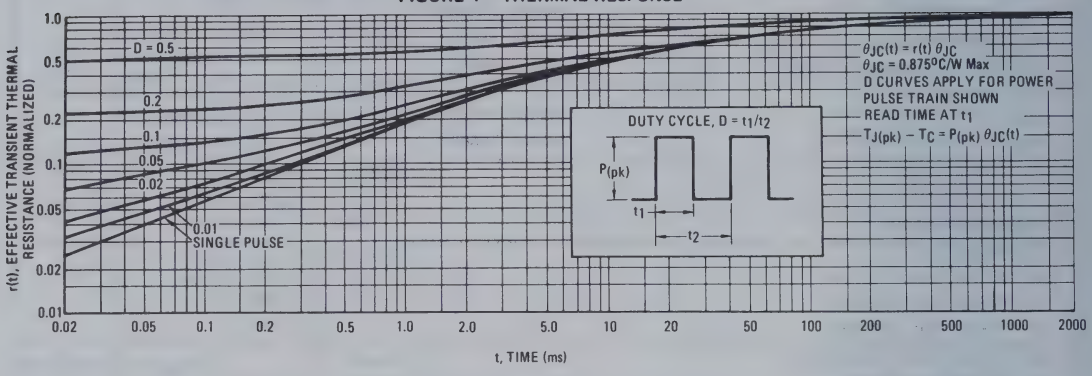
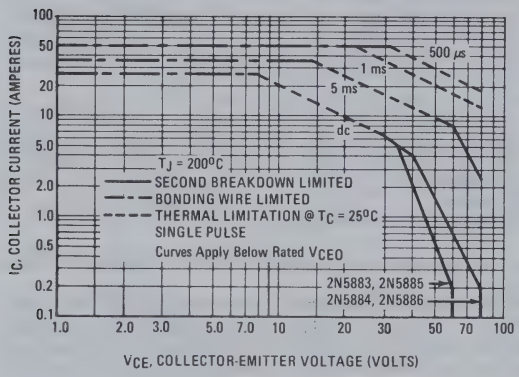


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415)

FIGURE 6 – TURN-OFF TIME

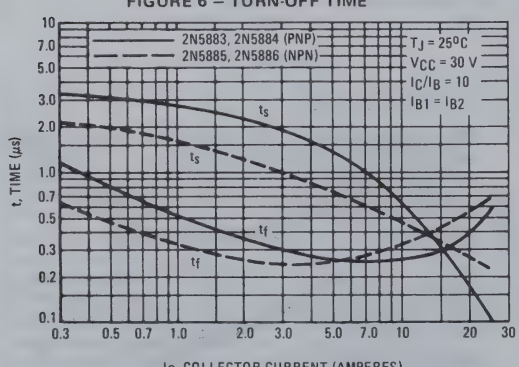
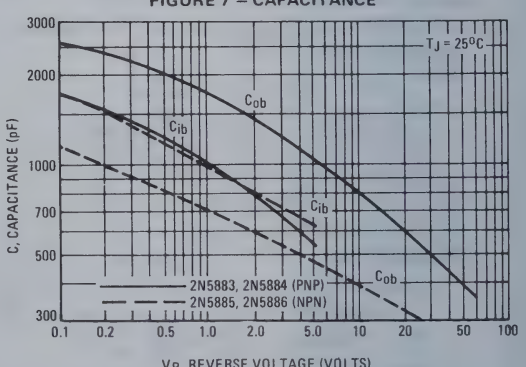


FIGURE 7 – CAPACITANCE



PNP DEVICES
2N5883 and 2N5884

NPN DEVICES
2N5885 and 2N5886

FIGURE 8 – DC CURRENT GAIN

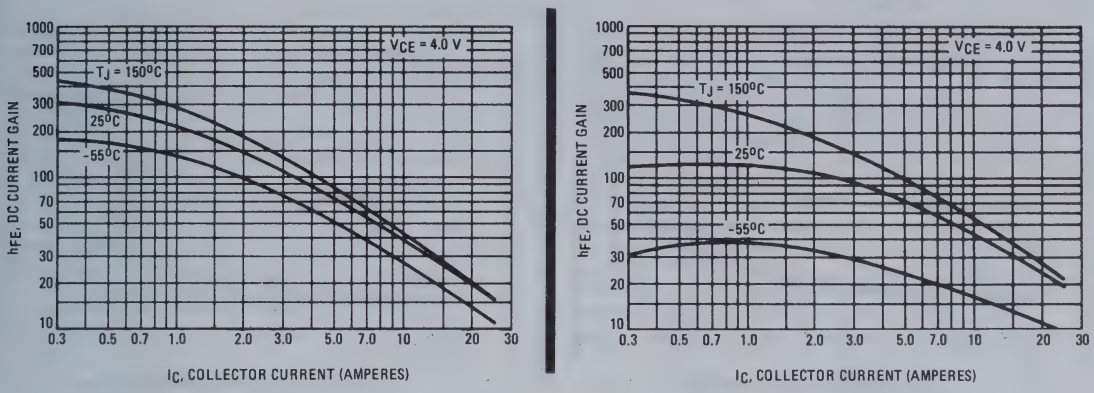


FIGURE 9 – COLLECTOR SATURATION REGION

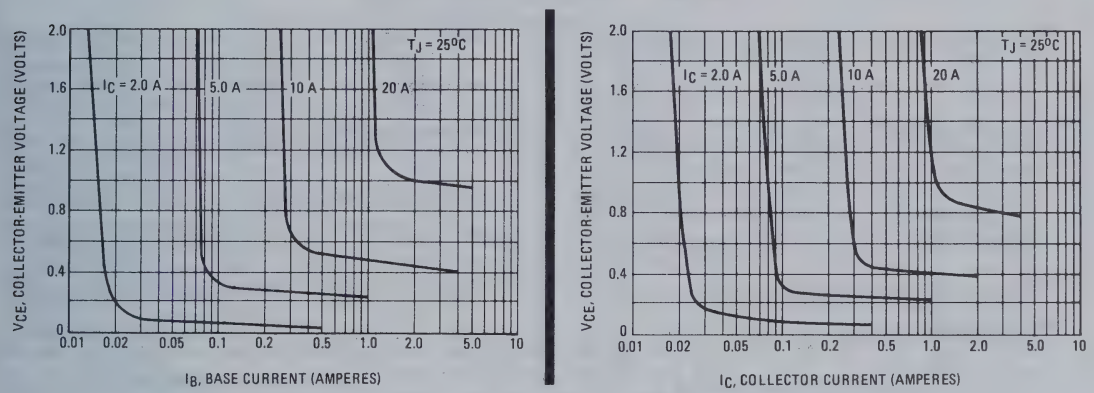
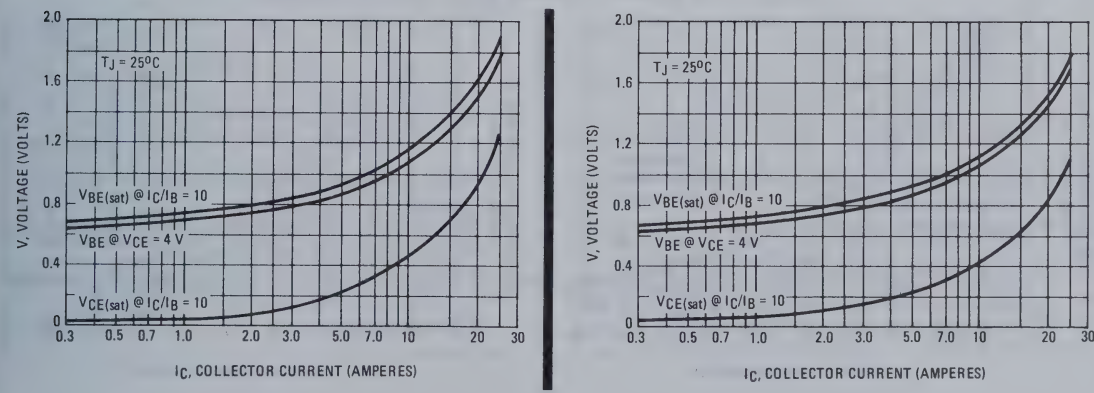


FIGURE 10 – "ON" VOLTAGES



PNP DEVICES
2N5883 and 2N5884

NPN DEVICES
2N5885 and 2N5886

FIGURE 11 – TEMPERATURE COEFFICIENTS

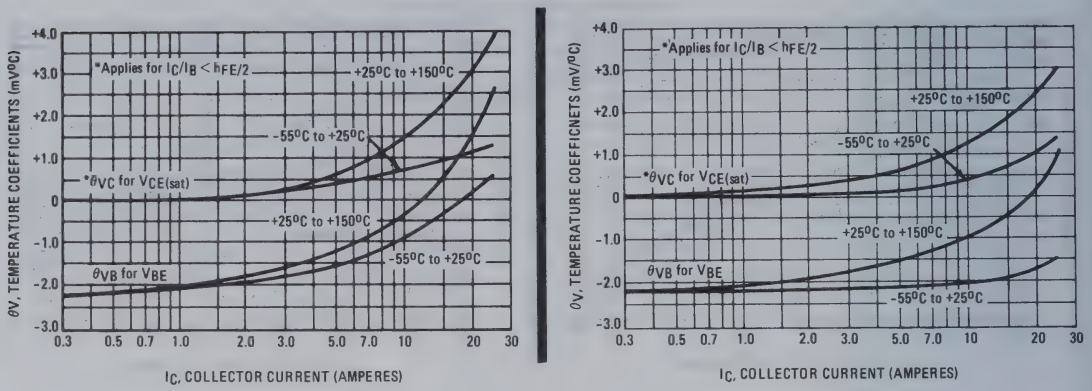


FIGURE 12 – COLLECTOR CUT-OFF REGION

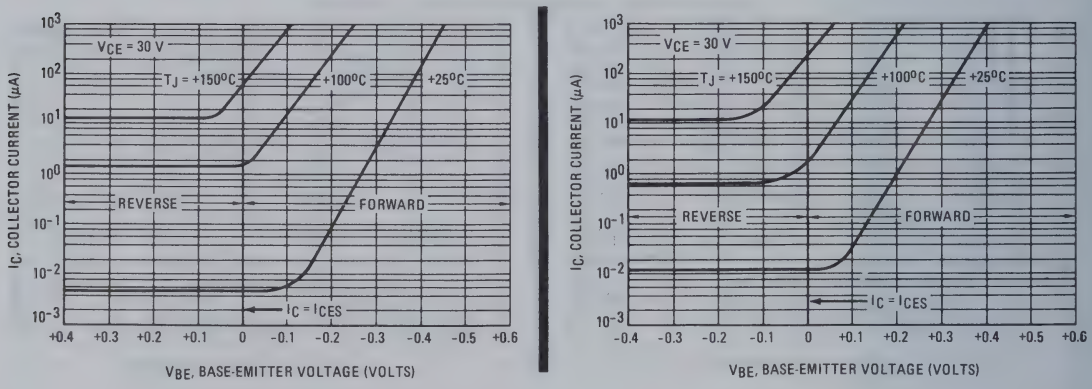
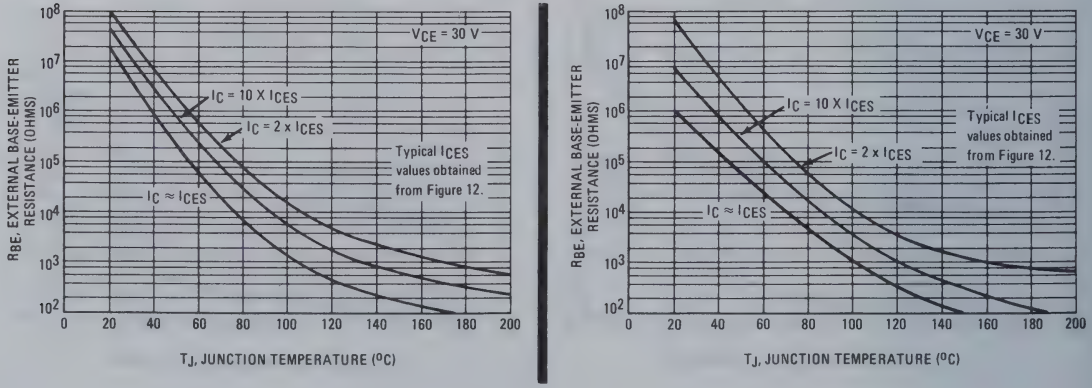


FIGURE 13 – EFFECTS OF EXTERNAL BASE-EMITTER RESISTANCE



2N5887 thru 2N5901 (GERMANIUM)

GERMANIUM PNP POWER TRANSISTORS

. . . designed for low frequency switching and amplifier applications requiring to 7.0 amperes collector current.

- Low Collector-Emitter Cutoff Current – I_{CEX} = 10 mA Max @ 100°C with V_{CE} to 75 V
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.4 V Max @ I_C = 7.0 A
- Broad Range of Current Gain Available
- TO-66 Cold Weld All Aluminum Package
- Electrically Similar to 2N3611 Series

7.0 AMPERE POWER TRANSISTORS

PNP GERMANIUM

20–75 VOLTS
57 WATTS



*MAXIMUM RATINGS

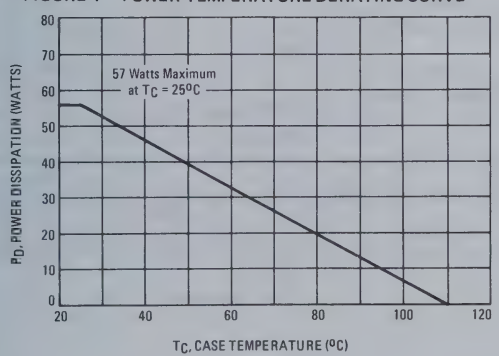
Rating	Symbol	2N5887	2N5888 2N5889 2N5893 2N5897 2N5901	2N5890 2N5894 2N5898	2N5891 2N5895 2N5899	2N5892 2N5896 2N5900	Unit
Collector-Emitter Voltage (Base Open)	V_{CEO}	15	25	35	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	20	30	45	60	75	Vdc
Collector-Base Voltage	V_{CBO}	20	30	45	60	75	Vdc
Emitter-Base Voltage	V_{EBO}	← 20 →					Vdc
Collector Current – Continuous	I_C	← 7.0 →					Adc
Base Current – Continuous	I_B	← 2.0 →					Adc
Operating Case and Storage Temperature Range	T_C, T_{stg}	← −65 to +110 →					°C
Total Device Dissipation @ T_C = 25°C	P_D	← 57 →					Watts
Derate above 25°C		← 0.67 →					W/°C

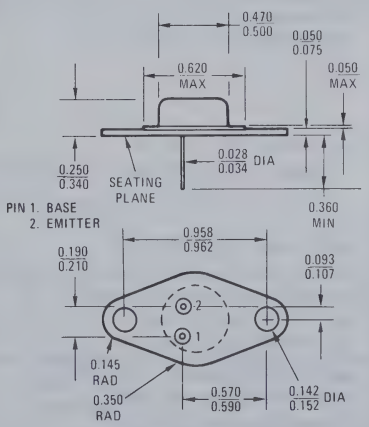
*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

Collector connected to case

CASE 80-02
TO-66

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}			Vdc
(I_C = 500 mAdc, I_B = 0)	2N5887		15	–	
	2N5888,89,93,97,2N5901		25	–	
	2N5890,94,98		35	–	
	2N5891,95,99		45	–	
	2N5892,96,2N5900		60	–	
Collector-Emitter Breakdown Voltage (1)		BV_{CES}			Vdc
(I_C = 250 mAdc, V_{BE} = 0)	2N5887		20	–	
	2N5888,89,93,97,2N5901		30	–	
	2N5890,94,98		45	–	
	2N5891,95,99		60	–	
	2N5892,96,2N5900		75	–	
Collector Cutoff Current		I_{CEO}	–	30	mAdc
(V_{CE} = 1/2 V_{CEO} Max)	All Types				
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = V_{CES} Max, V_{BE} = 1.0 Vdc)	All Types		–	5.0	
(V_{CE} = V_{CES} Max, V_{BE} = 1.0 Vdc, T_C = 100°C)	All Types		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2.0 Vdc)	All Types		–	0.06	
(V_{CB} = 15 Vdc)	2N5887		–	1.0	
(V_{CB} = 25 Vdc)	2N5888,89,93,97,2N5901		–	1.0	
(V_{CB} = 35 Vdc)	2N5890,94,98		–	1.0	
(V_{CB} = 45 Vdc)	2N5891,95,99		–	1.0	
(V_{CB} = 60 Vdc)	2N5892,96,2N5900		–	1.0	
Emitter Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{BE} = 20 Vdc, I_C = 0)	All Types				
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)	2N5887,88		15	350	
	2N5889,90,91,92		30	70	
	2N5893,94,95,96		60	120	
	2N5897,98,99,2N5900		100	200	
	2N5901		175	350	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N5887,88		10	–	
	2N5889,90,91,92		15	–	
	2N5893,94,95,96		30	–	
	2N5897,98,99,2N5900		50	–	
	2N5901		75	–	
(I_C = 7.0 Adc, V_{CE} = 2.0 Vdc)	2N5887,88		5.0	–	
	2N5889 thru 2N5901		10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 7.0 Adc, I_B = 1.4 Adc)	2N5887,88		–	0.4	
(I_C = 7.0 Adc, I_B = 700 mAdc)	2N5889 thru 2N5901		–	0.4	
Base-Emitter On Voltage		$V_{BE(on)}$	–	1.2	Vdc
(I_C = 7.0 Adc, V_{CE} = 2.0 Vdc)	All Types				
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	250	–	kHz
(I_C = 0.5 Adc, V_{CE} = 12 Vdc)	All Types				

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

FIGURE 2 – THERMAL RESPONSE

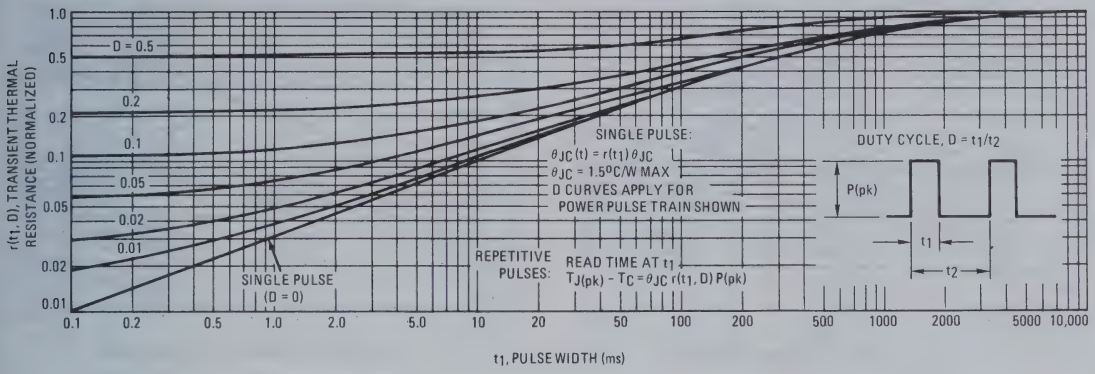


FIGURE 3 – CLAMPED INDUCTIVE SAFE OPERATING AREA

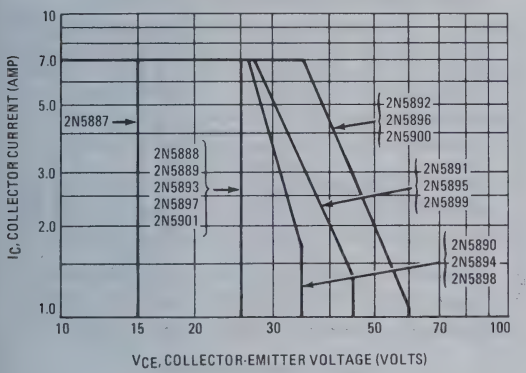


FIGURE 4 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT

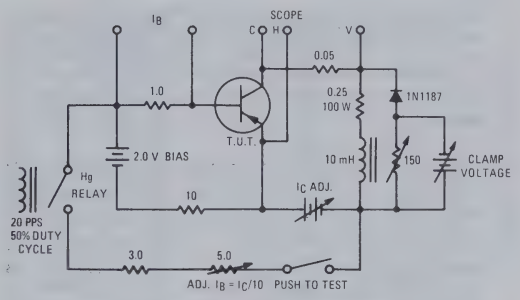


FIGURE 5 – SWITCHING TIMES

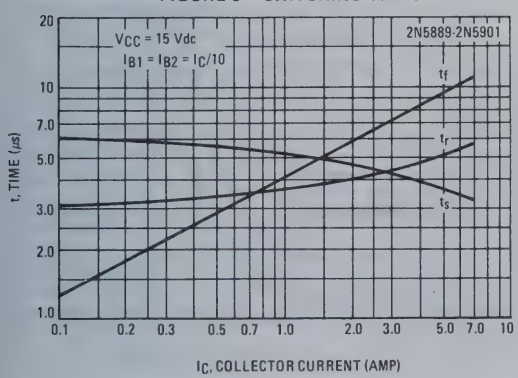


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

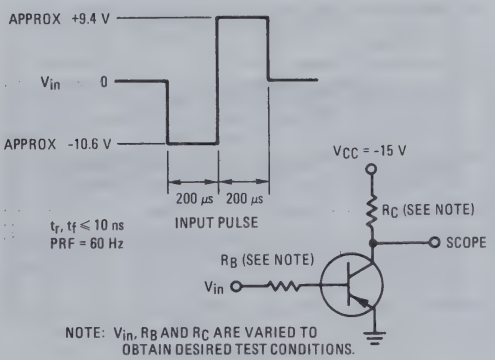


FIGURE 7 – ACTIVE-REGION SAFE-OPERATING AREA

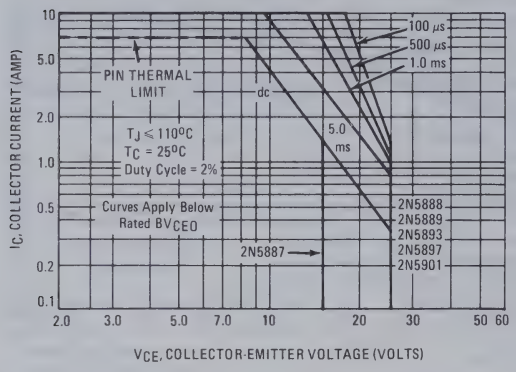


FIGURE 8 – ACTIVE-REGION SAFE-OPERATING AREA

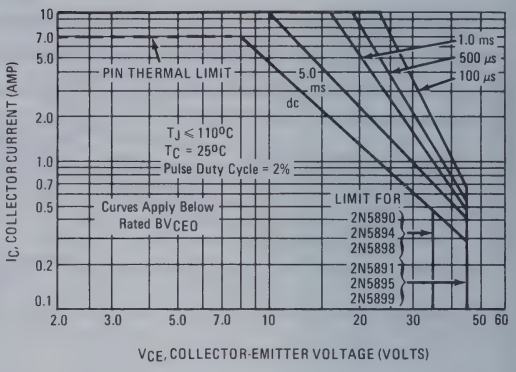


FIGURE 9 – ACTIVE-REGION SAFE-OPERATING AREA

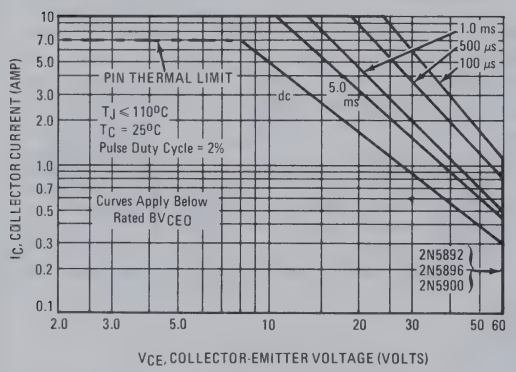


FIGURE 10 – CURRENT-GAIN–BANDWIDTH PRODUCT

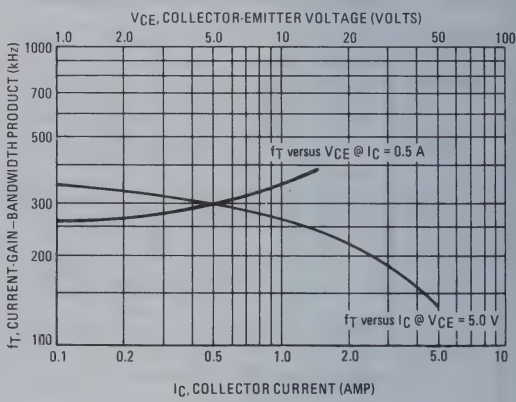


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

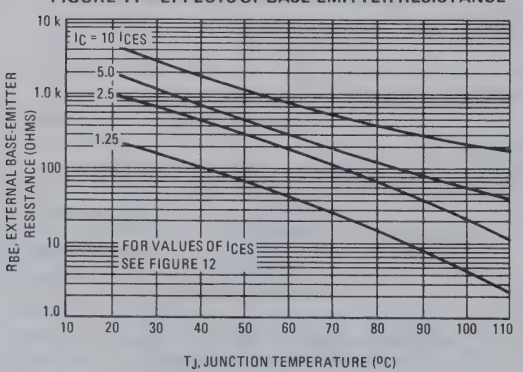


FIGURE 12 – COLLECTOR CUTOFF REGION

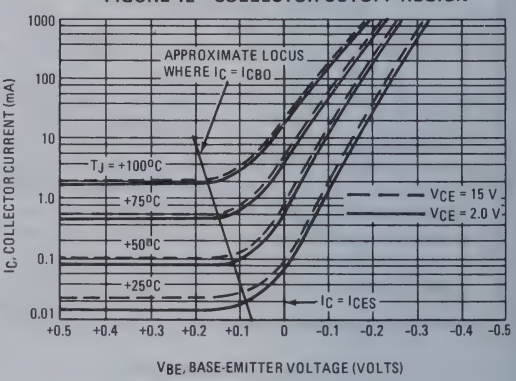


FIGURE 13 – DC CURRENT GAIN

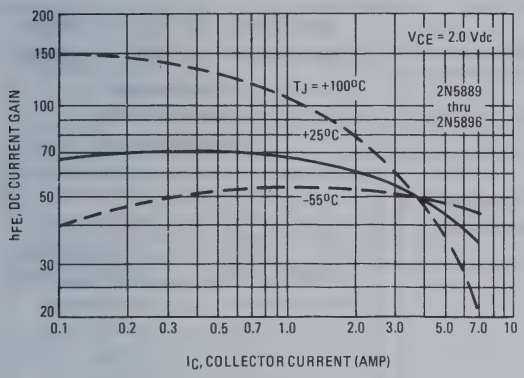


FIGURE 14 – DC CURRENT GAIN

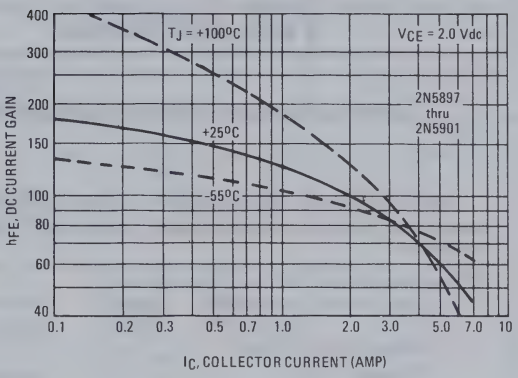


FIGURE 15 – COLLECTOR SATURATION REGION

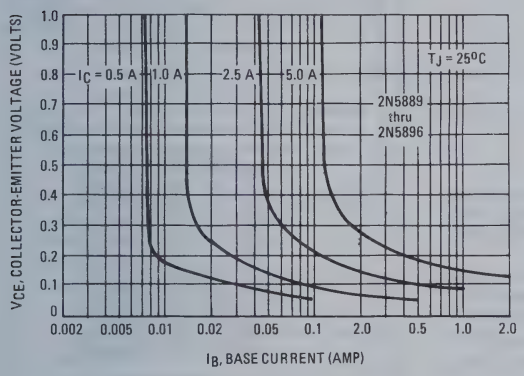


FIGURE 16 – COLLECTOR SATURATION REGION

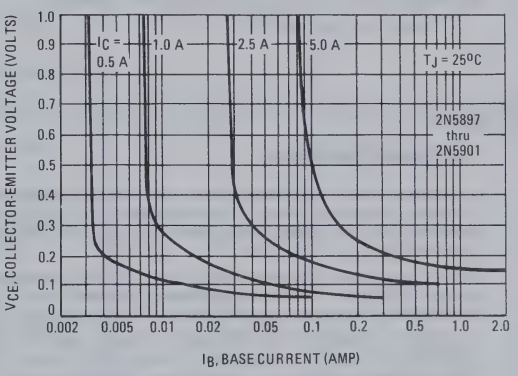


FIGURE 17 – "ON" VOLTAGES

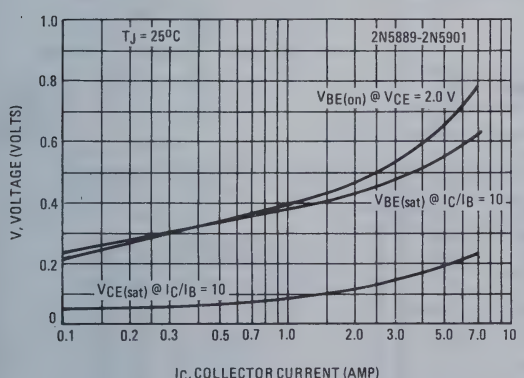
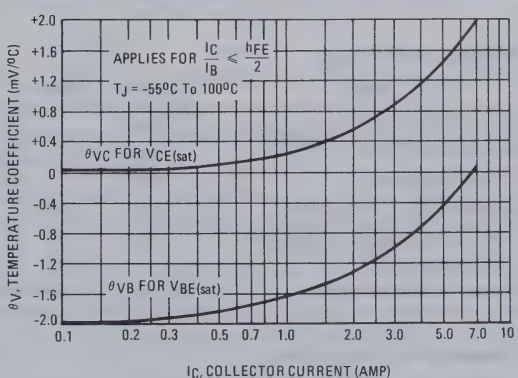


FIGURE 18 – TEMPERATURE COEFFICIENTS



2N5941 (SILICON)
2N5942

The RF Line

NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for applications as a high-power linear amplifier from 2.0 to 30 MHz, in single sideband mobile, marine and base station equipment.

- Specified 28 Volt, 30 MHz Characteristics –
  Output Power = 40 W (PEP) – 2N5941
  = 80 W (PEP) – 2N5942
  Minimum Gain = 13 dB
  Efficiency = 40%
  Intermodulation Distortion = -30 dB (Max)
- Isothermal-Resistor Design Results in Rugged Device
- 2N5942 Available as Matched Pairs for Push-Pull Amplifier Applications

MATCHING PROCEDURE

In the push-pull circuit configuration two device parameters are critical for optimum circuit performance. These parameters are $V_{BE(on)}$ and h_{FE}. Both parameters can be guaranteed by measuring I_{CQ} of the devices and selecting pairs with a $\Delta I_{CQ} \leqslant 10$ mAdc.

Actual I_{CQ} matching is performed in the 2N5942 test circuit with a V_{CE} equal to 28 Volts. The base bias supply is adjusted to set I_{CQ} equal to 40 mAdc using a reference standard 2N5942. The I_{CQ} of all production 2N5942 transistors is measured using this base bias supply setting. The production 2N5942's are tested and categorized in ranges of 10 mAdc. Finally, the devices are stocked as pairs with a guaranteed $\Delta I_{CQ} \leqslant 10$ mAdc.

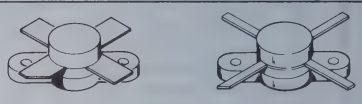
***MAXIMUM RATINGS**

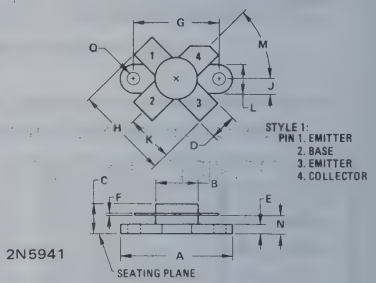
Rating	Symbol	2N5941	2N5942	Unit
Collector-Emitter Voltage	V_{CEO}	35		Vdc
Collector-Base Voltage	V_{CBO}	65		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current – Continuous	I_C	6.0	12	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	80 0.457	140 0.8	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200		^oC

*Indicates JEDEC Registered Data

These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

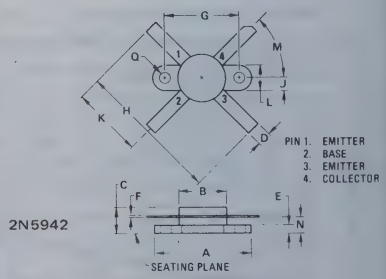
40 W (PEP)--30 MHz – 2N5941
80 W (PEP)–30 MHz – 2N5942
RF POWER TRANSISTORS
NPN SILICON





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	9.47	9.73	0.373	0.383
C	6.07	7.14	0.239	0.281
D	5.59	5.84	0.220	0.230
E	2.16	2.67	0.085	0.105
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	21.59	22.10	0.850	0.870
J	3.12	3.23	0.123	0.127
K	10.80	11.05	0.425	0.435
L	6.22	6.48	0.245	0.255
M	40°	50°	40°	50°
N	3.81	4.57	0.150	0.180
Q	2.97	3.12	0.117	0.123

CASE 211-01



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	11.81	12.07	0.465	0.475
C	5.82	6.73	0.229	0.265
D	2.16	3.94	0.085	0.155
E	2.13	2.54	0.084	0.100
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	35.56	38.10	1.400	1.500
J	3.12	3.23	0.123	0.127
K	17.78	19.05	0.700	0.750
L	6.22	6.48	0.245	0.255
M	40°	50°	40°	50°
N	3.66	4.32	0.144	0.170
Q	2.97	3.12	0.117	0.123

CASE 211-02

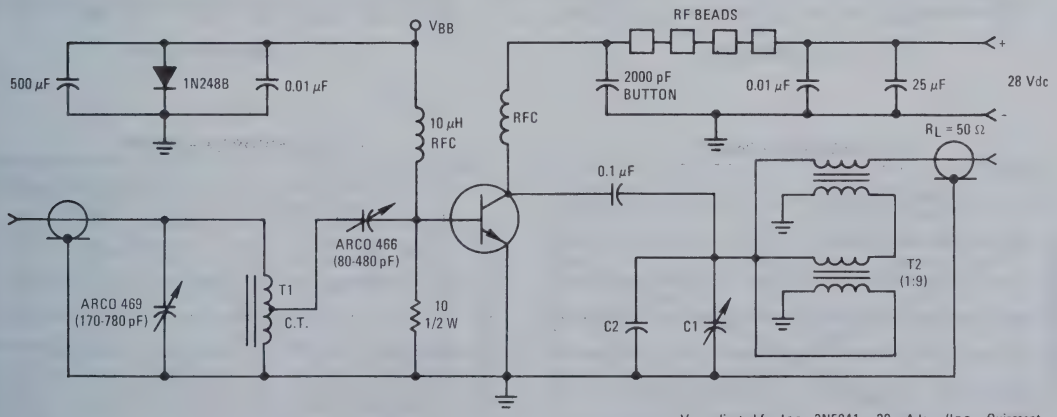
2N5941, 2N5942 (continued)

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)		BV_{CEO}	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)		BV_{CES}	65	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)		BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, V_{BE} = 0, T_C = +55°C)	2N5941 2N5942	I_{CES}	– –	5.0 10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	 2N5941 2N5942	h_{FE}	 10 10	 – –	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.25 Adc, V_{CE} = 15 Vdc, f = 50 MHz) (I_C = 0.5 Adc, V_{CE} = 15 Vdc, f = 50 MHz)	 2N5941 2N5942	f_T	 50 50	 – –	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	2N5941 2N5942	C_{ob}	– –	125 250	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 40 W (PEP), I_C = 1.78 Adc (Max), V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz) (P_{out} = 80 W (PEP), I_C = 3.575 Adc (Max), V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	 2N5941 2N5942	G_{PE}	 13 13	 – –	dB
Intermodulation Distortion Ratio (Figure 1) (P_{out} = 40 W (PEP), I_C = 1.78 Adc (Max), V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz) (P_{out} = 80 W (PEP), I_C = 3.575 Adc (Max), V_{CC} = 28 Vdc f_1 = 30 MHz, f_2 = 30.001 MHz)	 2N5941 2N5942	IMD	 – –	 -30 -30	dB
Collector Efficiency (P_{out} = 40 W (PEP), I_C = 1.78 Adc (Max), V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz) (P_{out} = 80 W (PEP), I_C = 3.575 Adc (Max), V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	 2N5941 2N5942	η	 40 40	 – –	%

* Indicates JEDEC Registered Data.

FIGURE 1 – 30 MHz TEST CIRCUIT



RFC: 20 TURNS #12 AWG ENAMELED WIRE CLOSE WOUND IN 2 LAYERS, 1/4" I.D.

T1: 20 TURNS #24 AWG WIRE WOUND ON MICRO-METALS T37-7 TOROID CORE CENTER TAPPED.

T2: 1:9 XFMR; 6 TURNS OF 2 TWISTED PAIRS OF #28 AWG ENAMELED WIRE. (8 CRESTS PER INCH) BIFILAR WOUND ON EACH OF 2 SEPARATE BALUN CORES. (Stackpole #57-1503, No. 14 Material) Interconnected as shown

RF BEADS: FERROXCUBE #56-590-65/3B

V_{BB} adjusted for I_{CQ}: 2N5941 – 20 mAdc (I_{CQ} = Quiescent Collector Current)
2N5942 – 40 mAdc

C1 – 2N5941 – 80-480 pF, ARCO 466 or Equiv
2N5942 – 170-780 pF, ARCO 469 or Equiv

C2 – 2N5941 – 220 pF
2N5942 – 330 pF

LINEAR OUTPUT POWER versus FREQUENCY

FIGURE 2 – 2N5941

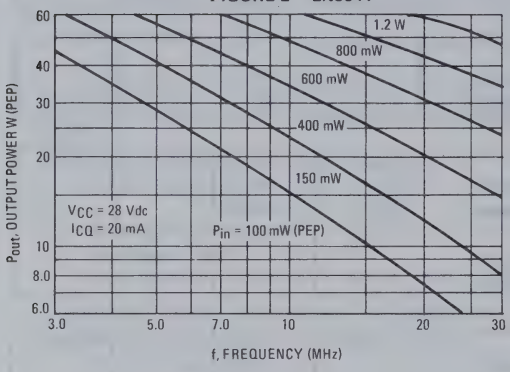
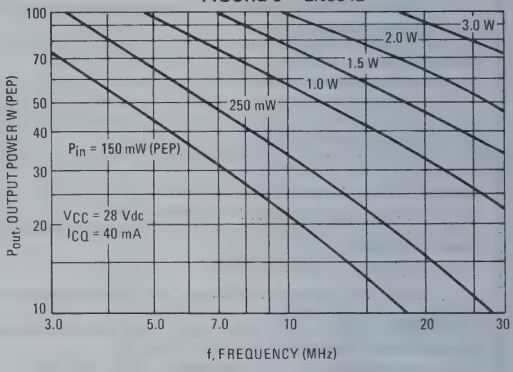


FIGURE 3 – 2N5942



OUTPUT POWER versus INPUT POWER

FIGURE 4 – 2N5941

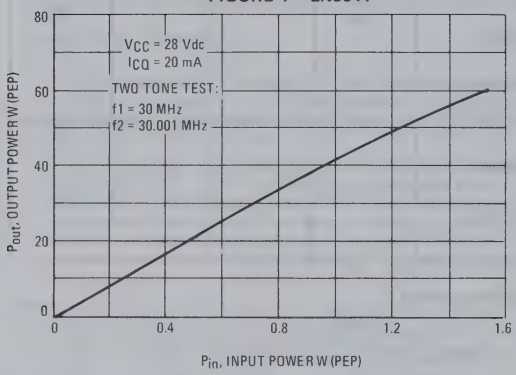


FIGURE 5 – 2N5942

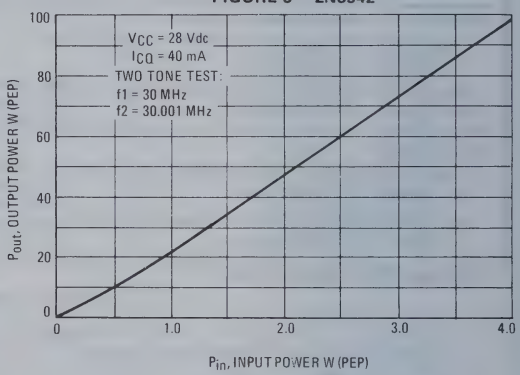


FIGURE 6 – 2N5941

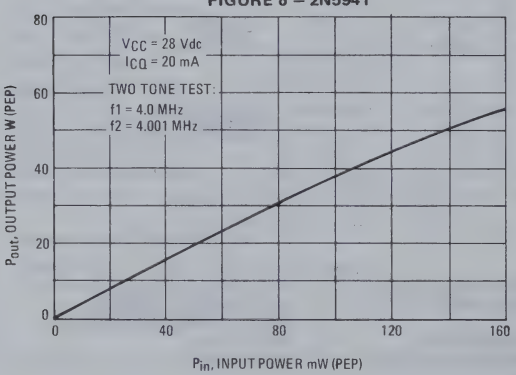
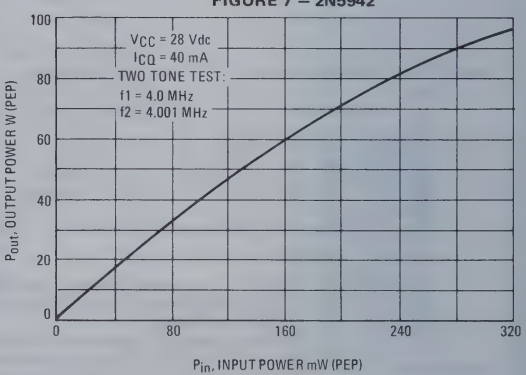


FIGURE 7 – 2N5942



INTERMODULATION DISTORTION versus OUTPUT POWER

(f1 = 30 MHz, f2 = 30.001 MHz)

FIGURE 8 – 2N5941

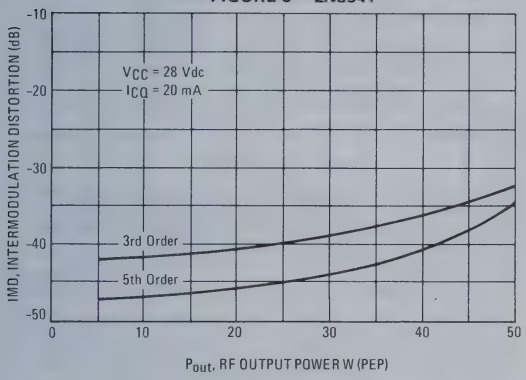
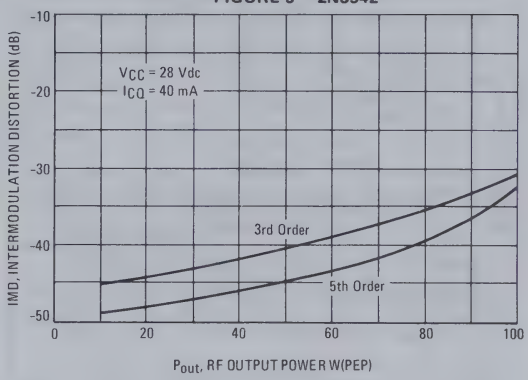


FIGURE 9 – 2N5942



LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

(f1 = 30 MHz, f2 = 30.001 MHz)

FIGURE 10 – 2N5941

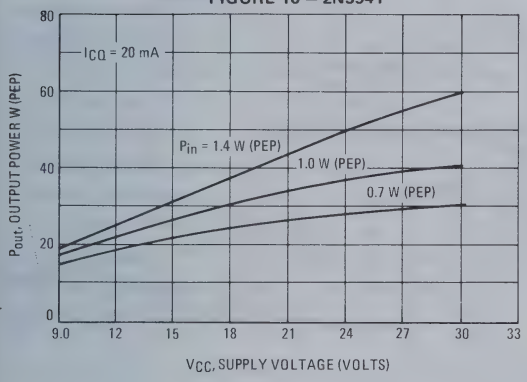


FIGURE 11 – 2N5942

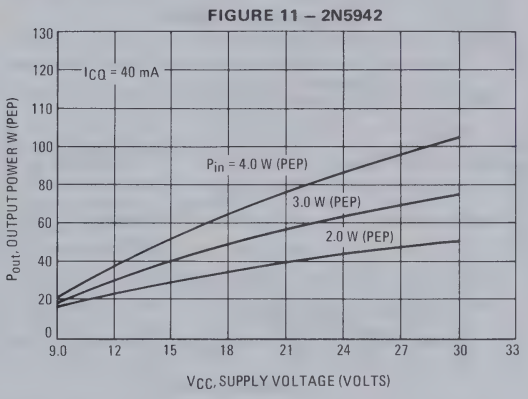


FIGURE 12 – 2N5941

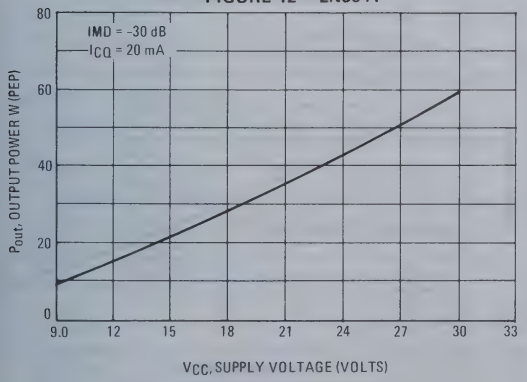
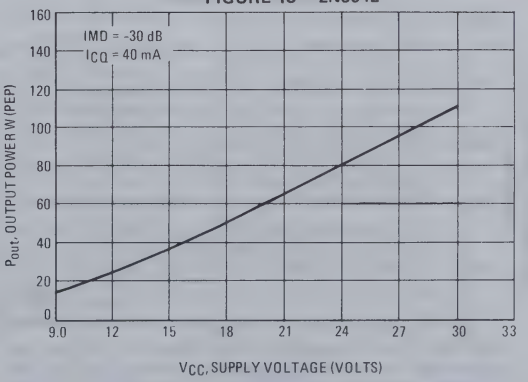


FIGURE 13 – 2N5942



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 14 – 2N5941

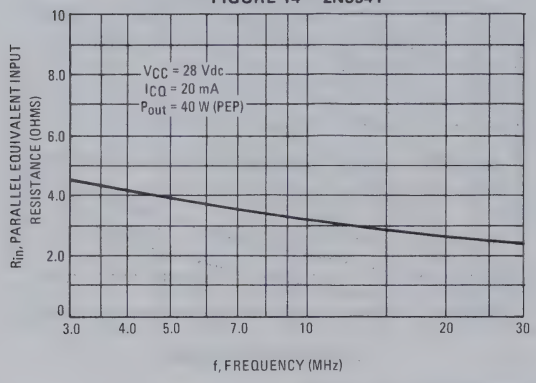
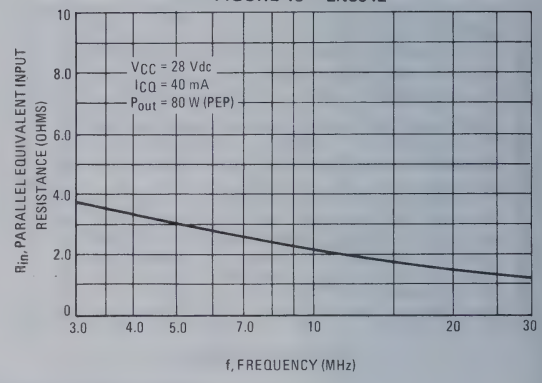


FIGURE 15 – 2N5942



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 16 – 2N5941

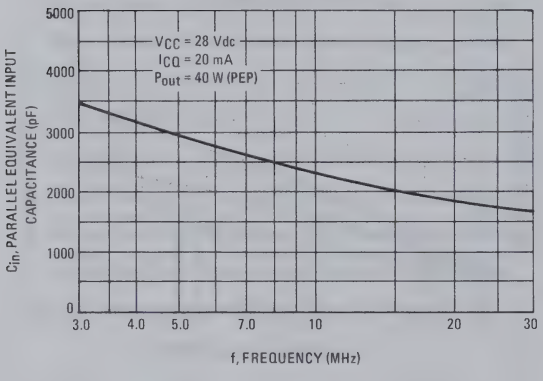
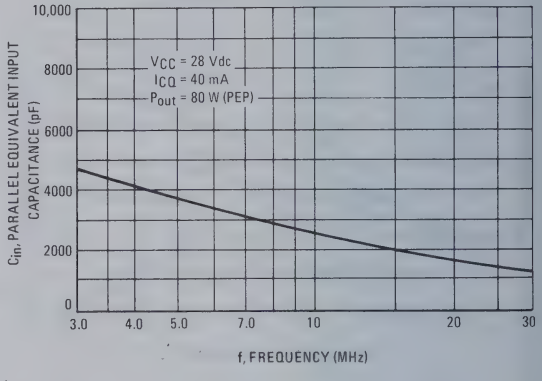


FIGURE 17 – 2N5942



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 18 – 2N5941

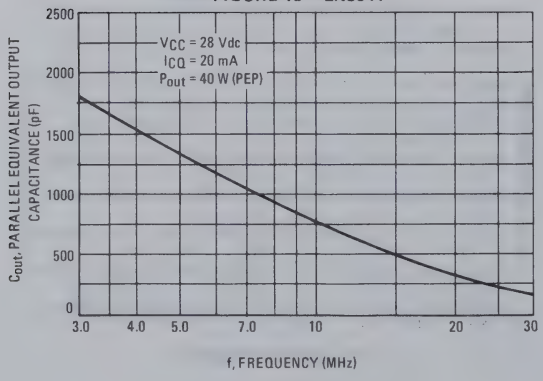
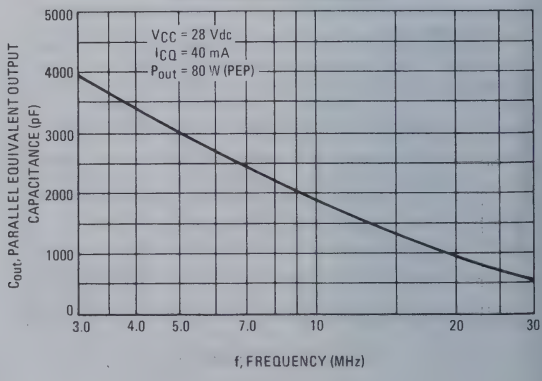


FIGURE 19 – 2N5942



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

FIGURE 20 – 2N5941

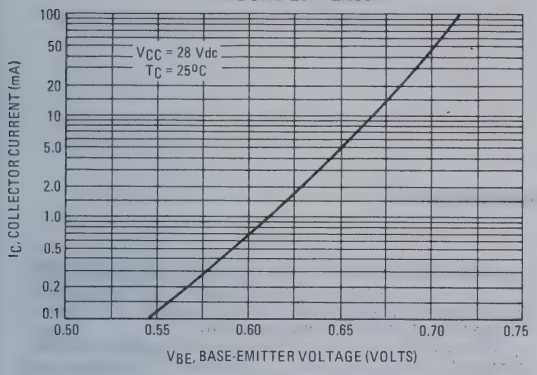
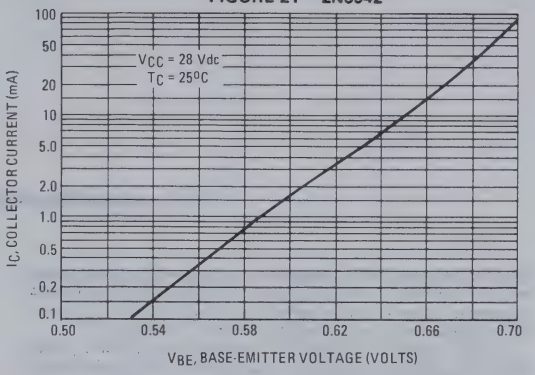


FIGURE 21 – 2N5942



SAFE OPERATING AREA

FIGURE 22 – 2N5941

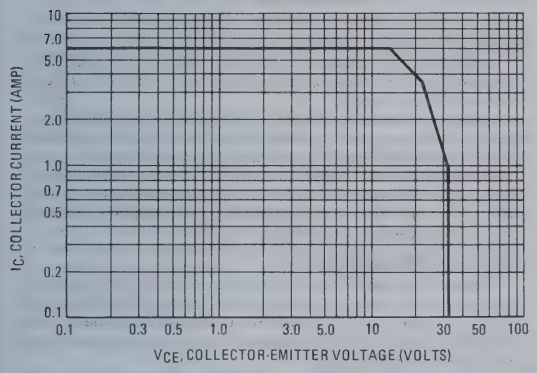


FIGURE 23 – 2N5942

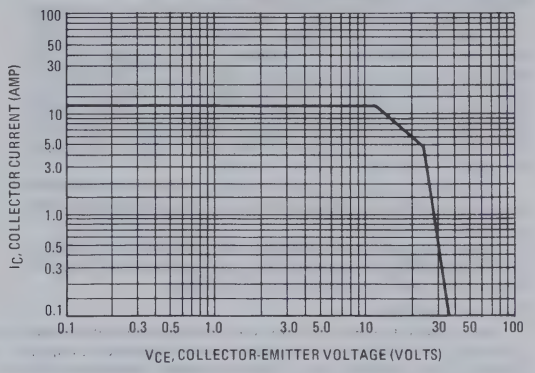
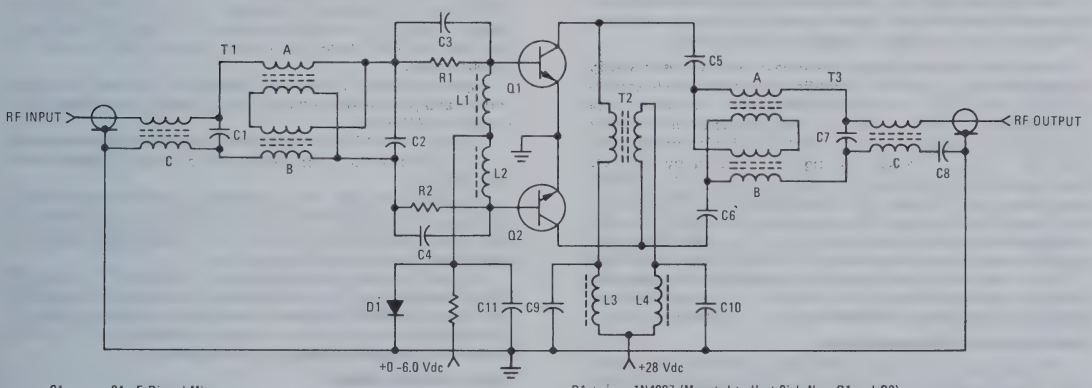


FIGURE 24 – PUSH-PULL 120-WATT PEP, 2-30 MHz LINEAR AMPLIFIER

G_{PE} = 13.5 dB, IMD = -31 dB (Typ)



C1	91 pF Dipped Mica
C2	680 pF Dipped Mica
C3,C4	3900 pF Ceramic (Total Lead Length to Bases Not to Exceed 3/4")
C5,C6	0.047 μF Polyester Film (Total Lead Length to Collectors Not to Exceed 1/2")
C7	27 pF Dipped Mica
C8	3300 pF Ceramic
C9,C10	0.33 μF Ceramic
C11	500 μF, 6.0 Volt Electrolytic
R1,R2	5.0 Ohm, (Two 10 Ohm, 1/2 Watt Carbon Resistors in Parrallel)
R3	20 Ohms, 10 Watts
L1,L2	10 μH Molded Chokes
L3,L4	FERROXCUBE VK200 19/4B (or 6 Ferrite Beads on #20 AWG)
D1	1N4997 (Mounted to Heat Sink Near Q1 and Q2)
Q1,Q2	2N5942 Matched Pair
T1	A and B Consist of 5 Turns of 4 Pairs of #32 AWG loosely twisted, Enameled Wires Wound on the Outer Toroids of INDIANA GENERAL TV Antenna Balum Core F684-1. C = 2 Pairs of #32 AWG Wound on the Inner Toroid of the Balum Core.
T2	Collector Choke, 4 Turns, 2 Twisted Pairs of #22 AWG Enameled Wire (4 Twists Per Inch), Wound on INDIANA GENERAL F627-8Q1 or Equivalent Toroid.
T3	A and B Consist of 5 Turns, 2 Twisted Pairs of #24 AWG, C Consists of 10 Turns, 1 Twisted Pair of #24 AWG Enameled Wire. (All Winding 6 Twists Per Inch) Core = INDIANA GENERAL F624-19Q1 or Equivalent.

NOTE: For more information on transformers, see AN-593, "Broadband Linear Power Amplifiers Using Push-Pull Transistors."

The maximum theoretical output from a 28 Volt push-pull amplifier, with a 1:4 output transformer, is 110-112 Watts, due to the limited voltage swing (assuming the transformer is a perfect 1:4). In most transmission line type transformers, the transformation ratio is usually higher, especially at the higher frequencies. Thus, depending on the amount of flat-topping that can be tolerated, and the compensation techniques of the transformer higher power outputs can be realized at reasonably low distortion. Ideally a 1:6 output transformer would be required for a power output of 150 Watt PEP.

APPLICATIONS INFORMATION

The 2N5941 and 2N5942 transistors are designed for linear power amplifier operation in the HF region (2 to 30 MHz). They feature guaranteed linear amplifier performance rather than the conventional performance demonstrated in a class C* amplifier.

Class C operation is inherently non-linear, but in many power amplifier applications non-linear operation does not present major problems. With a single frequency driving signal, the only spurious signals generated are harmonics and these can be suppressed in the amplifier tuned networks and output filter.

For single sideband (SSB), low level amplitude modulation (AM), and other types of complex signals, class C operation is generally not satisfactory. For instance, when a signal contains multiple frequencies at close spacings, odd-order non-linearities will generate spurious outputs which are within the passband of the tuned circuits and filters; therefore, the spurious outputs are not suppressed before they reach the antenna or other load. As a result, such complex signals require linear amplification if the amplified signal is to be free of spurious outputs.

A detailed analysis of spurious signals generated by non-linearities and linearity requirements of various applications is described in Chapter 12 of Reference 1.

The following discussion concerns itself with a detailed description of the 2N5941-2 characterization curves and general information on solid-state linear power amplifier design.

The Two-Tone Test

The 2N5941-42 functional test specification consists of a linear power amplifier test with guaranteed limits on power output, gain, efficiency, and intermodulation distortion (IMD) output levels. A two-tone test signal is used with the test amplifier as shown in Figure 1.

The two-tone test is one of many methods commonly used for testing linear amplifier performance. This test involves driving the amplifier with two RF signals, of equal amplitude, separated in frequency from each other by approximately 1 kHz.

When a two-tone test signal consisting of frequencies f_1 and f_2 is passed through a non-linear amplifier, odd order non-linearities generate spurious signals near the desired carrier. The level of these spurious signals provides a measure of the degree of non-linearity of the amplifier. This type of non-linearity is called intermodulation distortion (IMD). The spurious signals generated by IMD are further classified according to the exponential order of the amplifier non-linearity, i.e., 3rd order IMD products, 5th order IMD products, etc. The 3rd and 5th order IMD products are usually the most significant encountered with linear power amplifiers. Data on both 3rd and 5th order IMD are included in the 2N5941-42 characterization.

Third order IMD generates spurious signals near the operating frequency at frequencies $2f_1 - f_2$ and $2f_2 - f_1$; and 5th order IMD spurious signals are at frequencies $3f_1 - 2f_2$ and $3f_2 - 2f_1$.

Specifications and Characterization

The two-tone functional amplifier test is performed in a manner identical to the conventional class C functional test with two exceptions: a two-frequency signal is used in place of a single frequency, and amplifier linearity is added to the items tested and specified.

The functional test procedure for the 2N5941-42 requires driving the test amplifier with a two-frequency signal and measuring power output, gain, efficiency, and linearity.

Power output, gain, and efficiency measurement methods are the same for both linear and class C amplifiers.

Since a multiple frequency test signal has an instantaneous power level which varies with time, power levels are normally expressed in peak envelope power (PEP). This is the average power level of the envelope at its greatest amplitude point.

When the test signal consists of multiple signals with equal amplitudes and different frequencies, the relationship of average power and PEP is given by the following expression:

$$\text{Average power} = \frac{\text{PEP}}{N}$$

where N = the number of input frequencies.

Therefore, when measuring the power level of a standard two-tone test signal, a true average reading power meter will indicate 1/2 the PEP of the signal.

Linearity is tested by measuring the amplitudes of the 3rd and 5th order IMD products. The ratio of one of the 3rd order products to one of the two desired frequencies is then expressed as a power ratio in decibels (dB). This is repeated for the 5th order products. The smaller of these two ratios (usually the 3rd order) is then included in the electrical characteristics specification as intermodulation distortion ratio (IMD).

2N5941-42 Performance Curves

Figures 2 through 7 show typical power output and gain characteristics versus frequency and/or input power. These curves are similar to those found on other RF power transistor data sheets with one exception, a two-frequency test signal was used rather than a single frequency signal.

The curves shown in Figures 8 and 9 are unique to transistors characterized for linear power amplifier service and show the typical IMD levels versus power output.

The 2N5941-42 feature guaranteed IMD performance at the –30 dB level. However, the designer may desire IMD greater or less than –30 dB for a particular application. Figures 8 and 9 provide data on IMD levels that can be expected as a function of output power.

Figures 10 and 11 show the variation in gain with dc supply voltage and provide data on gain only. They do not include information on IMD ratio.

Figures 12 and 13 reflect the power output that can be obtained at a fixed IMD ratio for operation with dc supply voltages other than 28 Vdc.

Figures 14 through 19 show the large signal impedance characteristics of the 2N5941-42. These are similar to curves shown on other Motorola data sheets except a two-frequency test signal was used rather than a single frequency signal.

It must be stressed that the data shown in Figures 14 through 19 do not represent y, z, h, s, or any standard two-port parameter set. The actual transistor impedance levels during normal operation in an amplifier are given. For a detailed discussion of RF power transistor large signal impedance, see Reference 2.

Linear Amplifier Design

The following is a discussion of some general design considerations for solid-state linear power amplifiers. While this is not a detailed analysis of linear amplifier design, some general guidelines are provided.

The major difference between linear power amplifiers and class C power amplifiers is in the dc bias circuitry. As stated in the introduction, class C operation usually involves a collector dc supply as

APPLICATIONS INFORMATION (continued)

the only bias voltage with $V_E = V_B = 0$. The collector current is zero until the input RF signal turns the transistor "on".

In contrast, a linear amplifier is normally operated with forward bias and some collector current flowing when no signal is present.

The magnitude of no-signal collector current and the bias circuitry may vary with the application. Optimum no-signal collector currents for the 2N5941 and 2N5942 were found to be approximately 20 mA and 40 mA respectively.

The key to bias circuitry for good linearity lies in maintaining the base-emitter dc voltage relatively constant as the RF signal amplitude varies. The inherent nature of a forward-biased RF power transistor is to bias itself "off" with increasing RF drive signal. Therefore, a constant voltage source is required for base voltage.

Temperature effects also complicate the situation, since V_{BE} decreases with increasing temperature.

A simple solution to the bias problem involves the use of a forward-biased diode mounted on the transistor heat sink for thermal coupling to the transistor. A sample of this technique is shown in the test circuit of Figure 1. The capacitor in parallel with the diode helps maintain a constant V_{BE} with RF drive and improves linearity, while the diode provides temperature compensation to prevent thermal runaway. It is also possible to use complex active circuitry for biasing, and some rather exotic schemes have been developed to provide the same results.

Another important consideration is the collector-output network. Normally, a network with low impedance to ground for harmonics provides better linearity than a network with high harmonic impedances; therefore, some experimentation with network configuration is in order. Proper impedance matching remains the primary factor in both input and output network design. Further, it must also be stressed that the collector load impedance should be designed for the PEP, not the average power output. See Chapter 13 of Reference 1 for a detailed discussion of network design considerations.

Feedback may also be employed to improve linearity and may take the form of either neutralization or negative RF feedback. The possibilities here are limited only by the designer's imagination. Of course, negative RF feedback involves a decrease in gain to improve linearity.

REFERENCES

1. Pappenfus, Bruene, Schoenike, "Single Sideband Principles and Circuits", McGraw-Hill.
2. Hejhall, "Systemizing RF Power Amplifier Design", Motorola Semiconductor Products Inc., Application Note AN-282A.

*"Class C", as used here refers to operation with the no signal conditions $I_C = 0$, and $V_{BE} = 0$, and a theoretical conduction angle of less than 180^o, even though the actual conduction angle may be more than 180^o.

2N5943 (SILICON)

The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed specifically for broadband applications requiring low cross-modulation distortion and low-noise figure. Characterized for use in CATV applications. The 2N5943 was formerly MM8002.

- Low Noise Figure – @ f = 200 MHz
  NF (Narrowband) = 3.4 dB (Typ)
  NF (Broadband) = 6.8 dB (Typ)
- High Current-Gain – Bandwidth Product –
  f_T = 1200 MHz (Min) @ I_C = 50 mAdc
- Completely Characterized with S and Y-Parameters

NPN SILICON HIGH-FREQUENCY TRANSISTOR

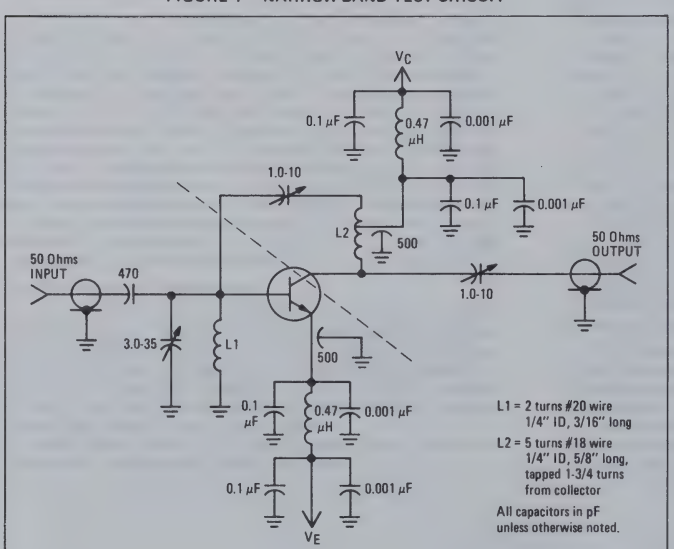


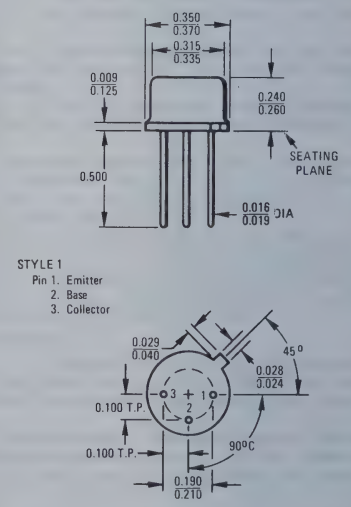
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

FIGURE 1 – NARROW-BAND TEST CIRCUIT





CASE 79(1)
(TO-39)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	500	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	μAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.15	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	–	0.88	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (Figure 2)	f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	1350	–	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1200	1550	2400	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	1425	–	
Collector-Base Capacitance (Figure 5) (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	1.0	1.6	2.5	pF
Emitter-Base Capacitance (Figure 5) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	8.4	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 1.0 kHz)	h_{fe}	25	–	350	–
Collector-Base Time Constant (I_E = 50 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	5.5	20	ps
Noise Figure	NF				dB
(I_C = 30 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1)		–	3.4	–	
(I_C = 35 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figures 6, 11, 14) (1)		–	6.8	8.0	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain	G_{pe}				dB
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) (Figure 1)		–	11.4	–	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 250 MHz) (Figure 6)		7.0	7.6	–	
Intermodulation Distortion (Figure 7) (I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)	IM	–	–	-50	dB
Cross Modulation Distortion (Figure 8)	XM				dB
(I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +40 dBmV)		–	-67	–	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, V_{out} = +50 dBmV)		–	-42	-45	

*Indicates JEDEC Registered Data.

(1) Includes noise figure of post-amplifier and matching pad.

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

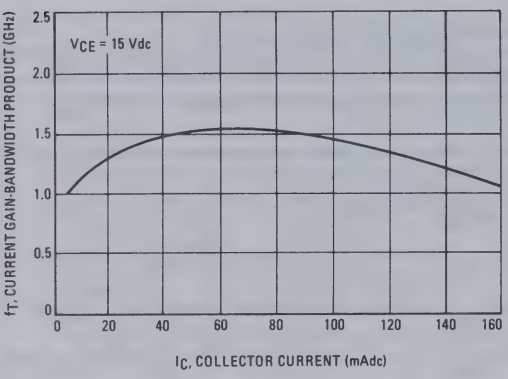


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT

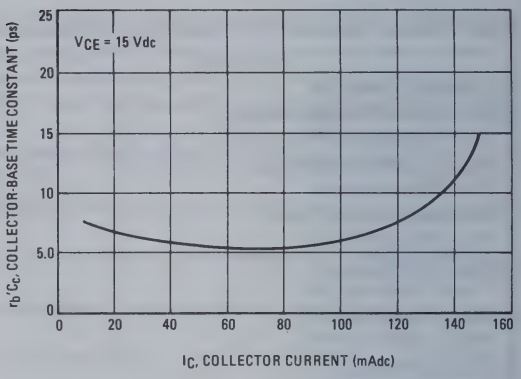


FIGURE 4 – SATURATION VOLTAGES

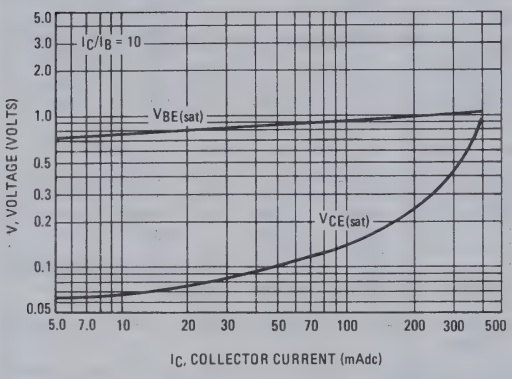


FIGURE 5 – CAPACITANCES versus REVERSE VOLTAGE

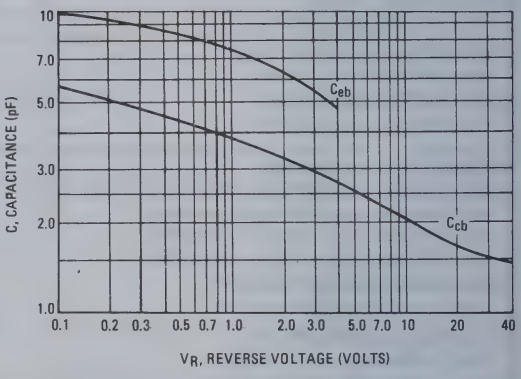
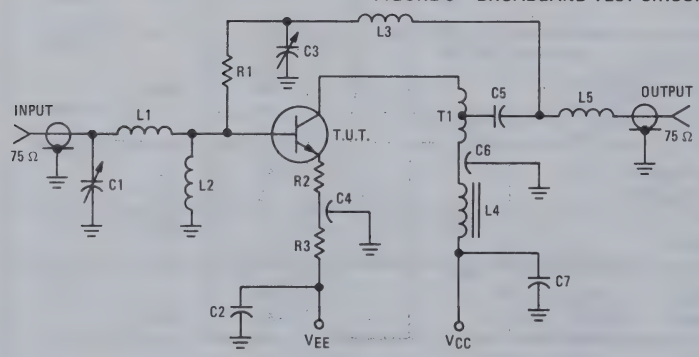


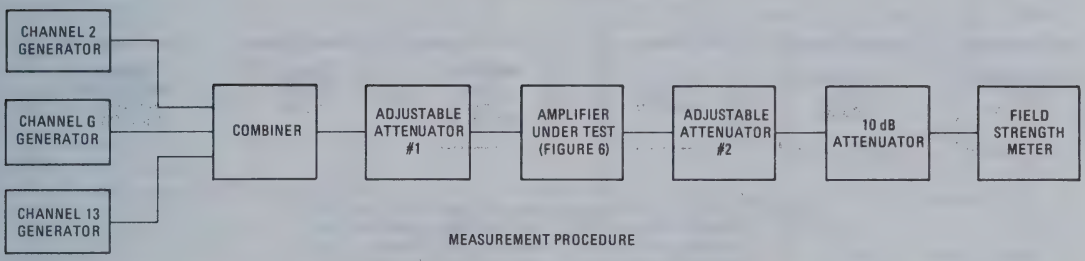
FIGURE 6 – BROADBAND TEST CIRCUIT



C1	1.0-10 pF	JOHANSON 2951 OR EQUIVALENT
C2, C7	0.01 μF	
C3	0.5-6.0 pF	JOHANSON 4642 OR EQUIVALENT
C4, C6	1500 pF	
C5	470 pF	
L1	2 TURNS AWG #26, 5/32" I.D.	
L2	1 μH MOLDED CHOKE	
L3	5 TURNS AWG #26, 3/32" I.D.	
L4	FERRITE CHOKE, 3 TURNS #30 ON STACKPOLE 57-0156 BEAD	
L5	2 TURNS AWG #26, 3/32" I.D.	
T1	AWG #30 TRIFILAR WOUND 1-9-9 ON STACKPOLE 57-0985, #11 TOROID	
R1	270 OHMS	
R2	18 OHMS	
R3	150 OHMS	

GARLOCK TEFLON SOCKET

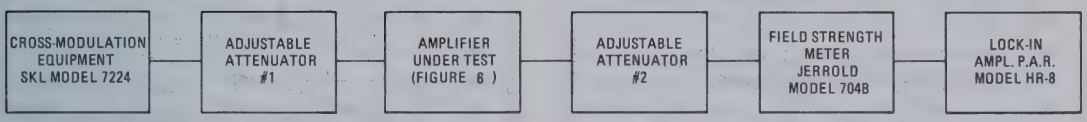
FIGURE 7 – INTERMODULATION DISTORTION TEST SETUP AND PROCEDURE



MEASUREMENT PROCEDURE

1. ADJUST CHANNEL 2 GENERATOR FOR RATED OUTPUT FROM TEST AMPLIFIER (CHANNELS G & 13 OFF).
2. REPEAT FOR CHANNEL G (2 & 13 OFF) AND CHANNEL 13 (2 & G OFF). NOTE FOR REFERENCE THE FIELD STRENGTH METER READING FOR CHANNEL 13 (2 & G OFF).
3. TURN CHANNEL 13 OFF AND DRIVE THE TEST AMPLIFIER WITH CHANNELS 2 & G. MEASURE THE LEVEL OF INTERMODULATION DISTORTION AT CHANNEL 13 RELATIVE TO THE REFERENCE LEVEL IN STEP 2.

FIGURE 8 – CROSS-MODULATION DISTORTION TEST SETUP AND PROCEDURE



MEASUREMENT PROCEDURE

1. ADJUST THE CROSSMODULATION EQUIPMENT FOR +40 dBmV OUTPUT FROM EACH CHANNEL.
2. ADJUST ATTENUATOR #1 FOR THE DESIRED OUTPUT LEVEL FROM THE TEST AMPLIFIER. ADJUST ATTENUATOR #2 TO MAINTAIN THE FIELD STRENGTH METER INPUT AT +10 dBmV.
3. WITH THE FIELD STRENGTH METER SELECT CHANNEL 13. USING THE WAVE ANALYZER MEASURE THE LEVEL OF THE MODULATION ON CHANNEL 13 DUE TO CROSS-MODULATION OF CHANNELS 2-12.

FIGURE 9 – CROSS-MODULATION DISTORTION versus COLLECTOR CURRENT

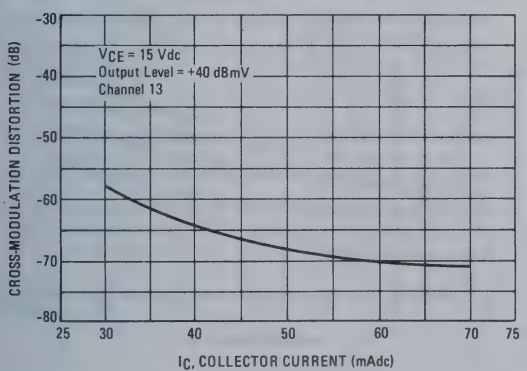


FIGURE 10 – CROSS-MODULATION DISTORTION versus OUTPUT LEVEL

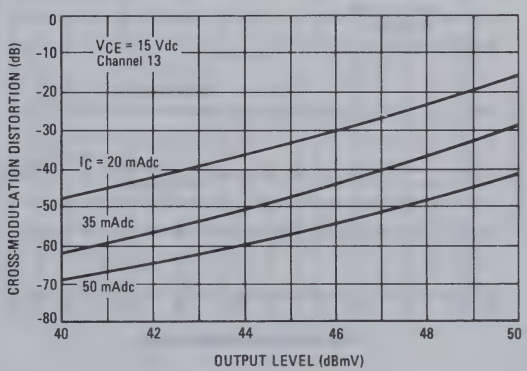
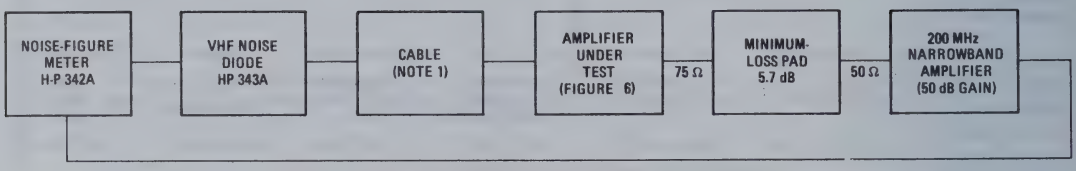


FIGURE 11 – NOISE FIGURE TEST SETUP



NOTE 1. RG-59 CABLE WITH ORIGINAL CENTER CONDUCTOR REPLACED WITH #30 WIRE. OVERALL LENGTH, INCLUDING BNC CONNECTORS, IS A QUARTER-WAVELENGTH AT 200 MHz (APPROX. 11 INCHES). USED TO MATCH IMPEDANCE OF NOISE DIODE TO AMPLIFIER UNDER TEST.

THE NOISE FIGURE OF THE POST-AMPLIFIER AND MINIMUM LOSS PAD IS 8.4 dB.

FIGURE 12 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

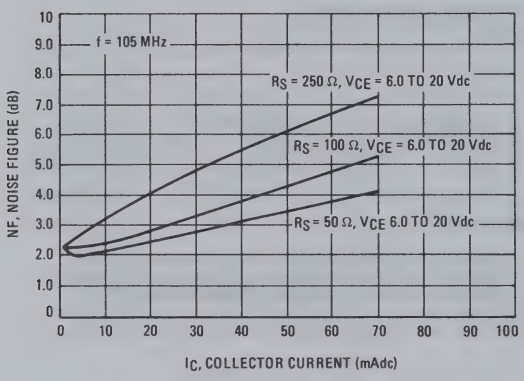


FIGURE 13 – NARROWBAND NOISE FIGURE versus COLLECTOR CURRENT

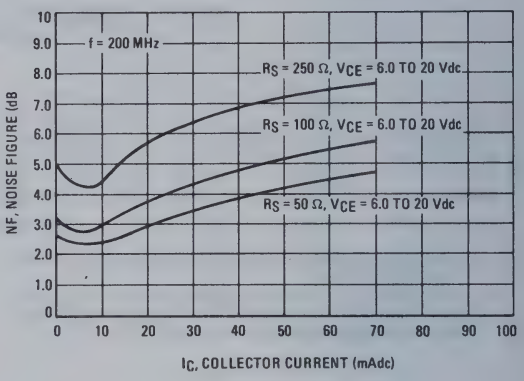


FIGURE 14 – BROADBAND NOISE FIGURE versus COLLECTOR CURRENT

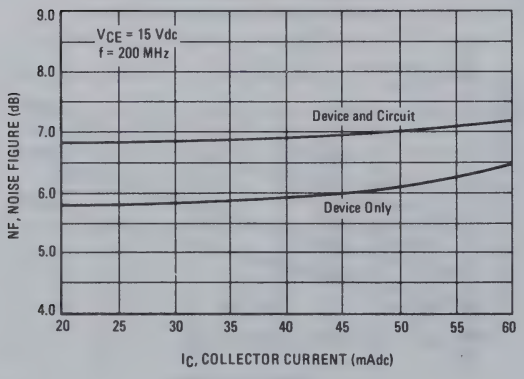


FIGURE 15 – NARROWBAND NOISE FIGURE versus FREQUENCY

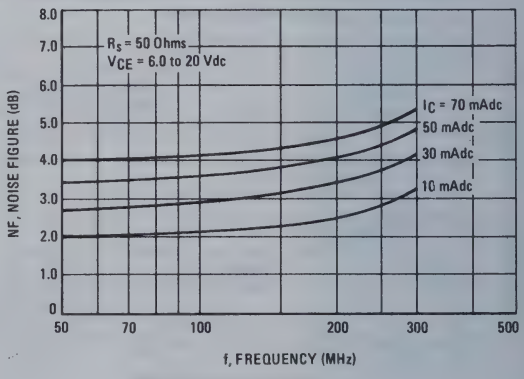


FIGURE 16 – INPUT ADMITTANCE versus FREQUENCY

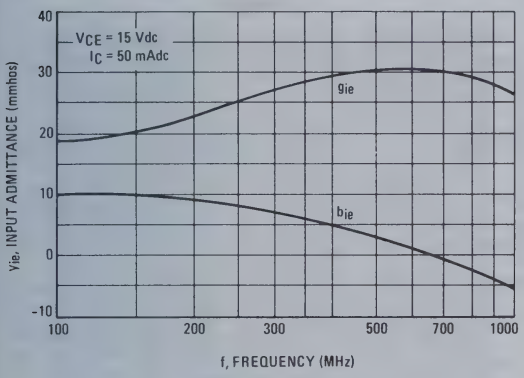


FIGURE 17 – INPUT ADMITTANCE versus COLLECTOR CURRENT

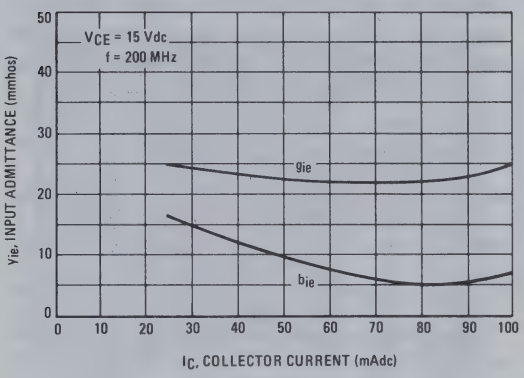


FIGURE 18 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

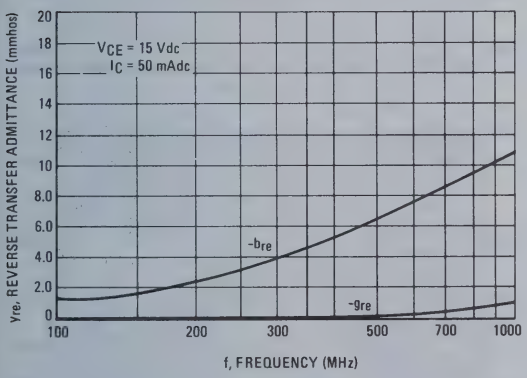


FIGURE 19 – REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

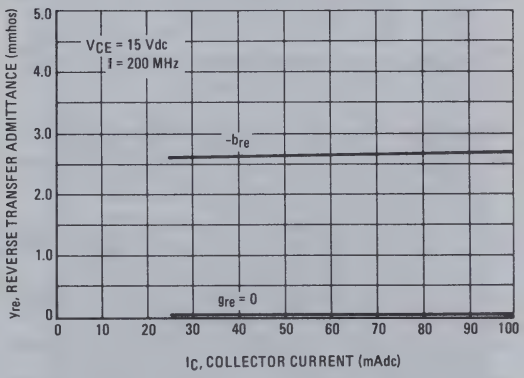


FIGURE 20 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

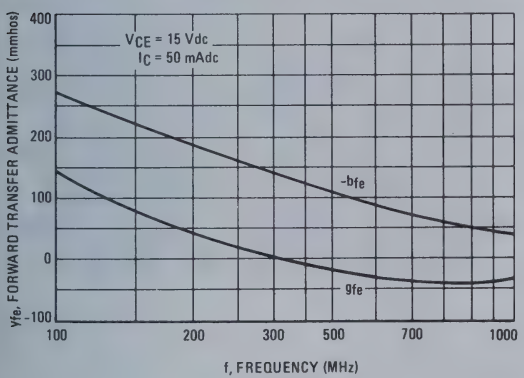


FIGURE 21 – FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

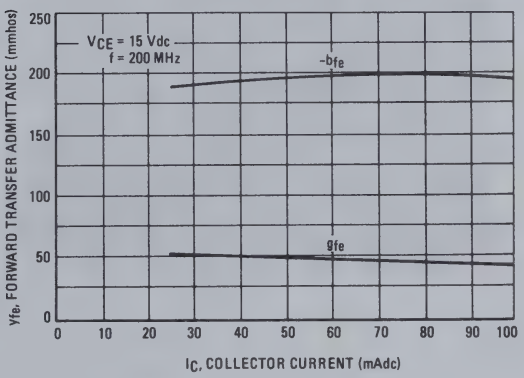


FIGURE 22 – OUTPUT ADMITTANCE versus FREQUENCY

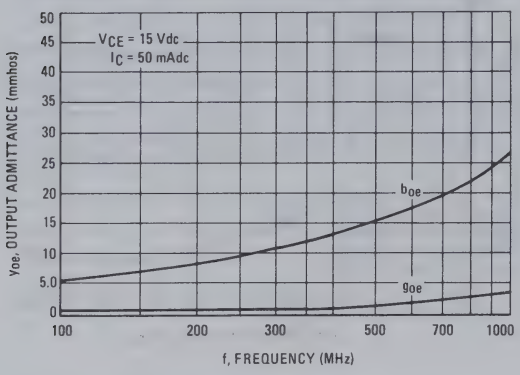


FIGURE 23 – OUTPUT ADMITTANCE versus COLLECTOR CURRENT

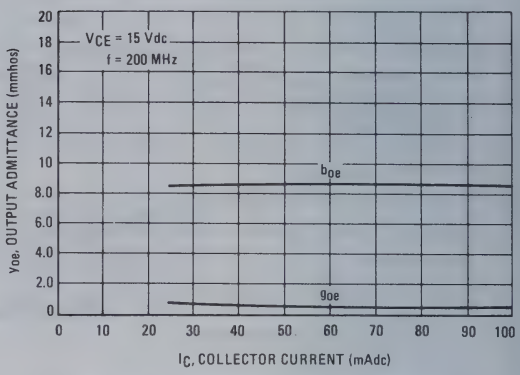


FIGURE 24 – INPUT REFLECTION COEFFICIENT versus FREQUENCY

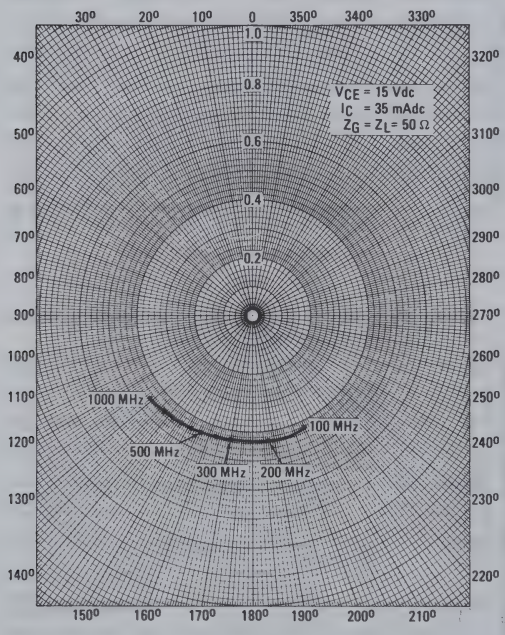


FIGURE 25 – OUTPUT REFLECTION COEFFICIENT versus FREQUENCY

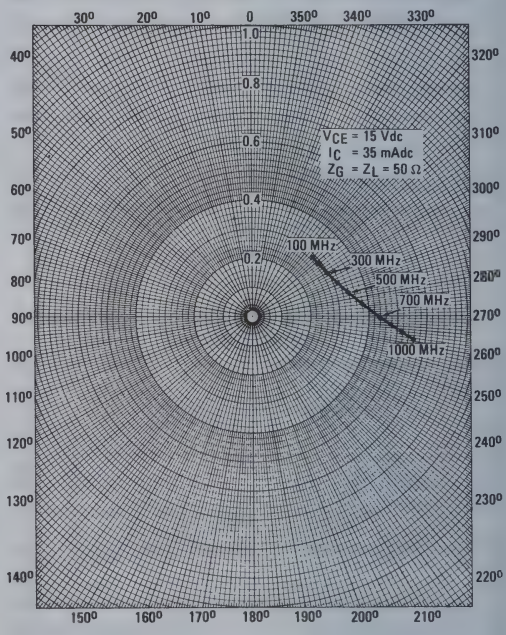


FIGURE 26 – REVERSE TRANSMISSION COEFFICIENT versus FREQUENCY

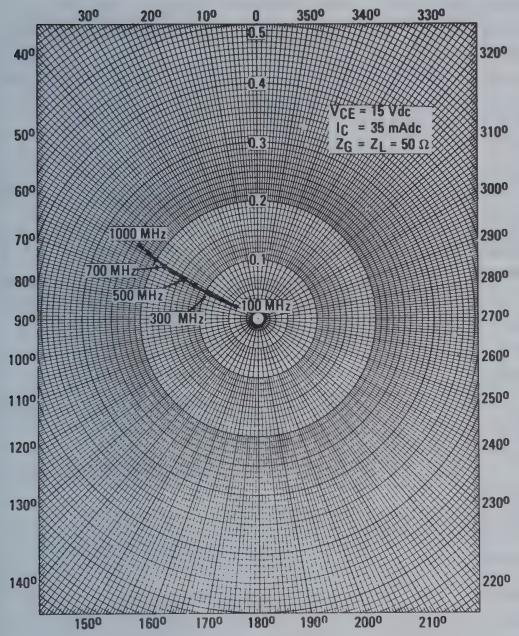


FIGURE 27 – FORWARD TRANSMISSION COEFFICIENT versus FREQUENCY

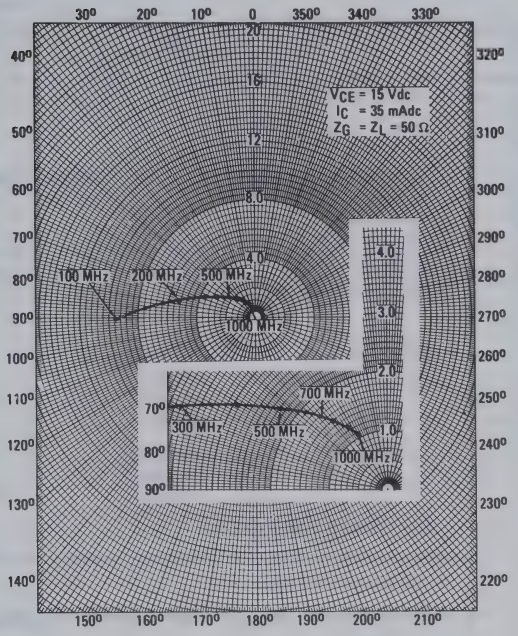
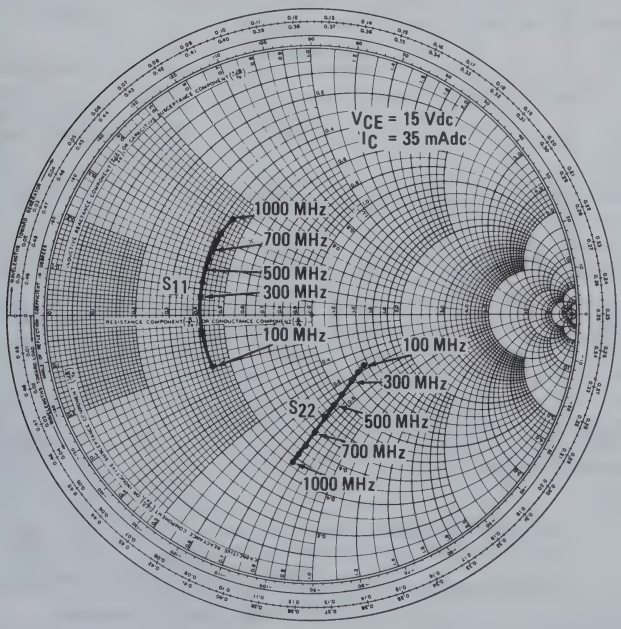


FIGURE 28 – INPUT REFLECTION COEFFICIENT AND OUTPUT REFLECTION COEFFICIENT versus FREQUENCY



2N5944 (SILICON)
2N5945
2N5946

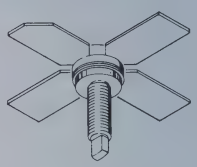
The RF Line

NPN SILICON RF POWER TRANSISTORS

. . . designed for 7.0 to 15 Volts, UHF large signal amplifier applications required in industrial and commercial FM equipment operating in the 400 to 960 MHz range.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Power Output = 2.0 W – 2N5944
  4.0 W – 2N5945
  10 W – 2N5946
  Minimum Gain = 9.0 dB – 2N5944
  8.0 dB – 2N5945
  6.0 dB – 2N5946
  Efficiency = 60% Minimum
- RF ballasting provides protection against device damage due to load mismatch
- Characterized with series equivalent large-signal impedance parameters

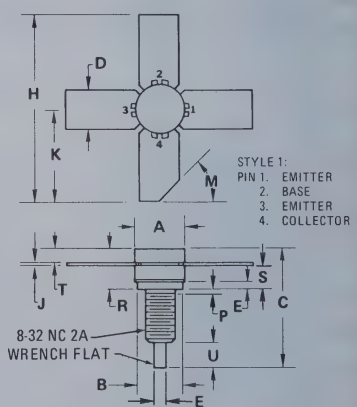
2.0, 4.0, 10 W – 470 MHz
RF POWER TRANSISTORS
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	2N5944	2N5945	2N5946	Unit
*Collector-Emitter Voltage	V_{CEO}	← 16 →			Vdc
*Collector-Base Voltage	V_{CBO}	← 36 →			Vdc
*Emitter-Base Voltage	V_{EBO}	← 4.0 →			Vdc
*Collector Current – Continuous	I_C	0.4	0.8	2.0	Adc
*Total Device Dissipation @ $T_C = 25^oC$(1)	P_D	5.0	15	37.5	Watts
Derate above 25^oC		28.5	85.5	214	$mW/^oC$
*Storage Temperature Range	T_{stg}	← −65 to +200 →			^oC
Stud Torque(2)	–	← 6.5 →			in-lbs.

*Indicates JEDEC Registered Data
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.
(2) For repeated assembly use 5 in-lbs.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	5.59	5.84	0.220	0.230
E	1.52 NOM		0.060 NOM	
H	26.80	27.05	1.055	1.065
J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 50 mAdc, I_B = 0)	2N5944		16	–	–	
(I_C = 100 mAdc, I_B = 0)	2N5945		16	–	–	
(I_C = 200 mAdc, I_B = 0)	2N5946		16	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 50 mAdc, V_{BE} = 0)	2N5944		36	–	–	
(I_C = 100 mAdc, V_{BE} = 0)	2N5945		36	–	–	
(I_C = 200 mAdc, V_{BE} = 0)	2N5946		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N5944		4.0	–	–	
(I_E = 2.0 mAdc, I_C = 0)	2N5945		4.0	–	–	
(I_E = 4.0 mAdc, I_C = 0)	2N5946		4.0	–	–	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	2N5944		–	0.2	10	
	2N5945,2N5946		–	0.5	20	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N5944,2N5945		–	–	1.0	
	2N5946		–	–	2.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N5944		20	80	–	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	2N5945		20	80	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5946		20	80	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	2N5944		–	11	15	
	2N5945		–	18	25	
	2N5946		–	38	45	
FUNCTIONAL TEST (Figure 20)						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(V_{CC} = 12.5 Vdc, P_{out} = 2.0 W, I_C(max) = 267 mAdc, f = 470 MHz)	2N5944		9.0	10	–	
(V_{CC} = 12.5 Vdc, P_{out} = 4.0 W, I_C(max) = 533 mAdc, f = 470 MHz)	2N5945		8.0	9.0	–	
(V_{CC} = 12.5 Vdc, P_{out} = 10 W, I_C(max) = 1.33 Adc, f = 470 MHz)	2N5946		6.0	7.0	–	
Collector Efficiency		η				%
(V_{CC} = 12.5 Vdc, P_{out} = 2.0 W, I_C(max) = 240 mAdc, f = 470 MHz)	2N5944		60	–	–	
(V_{CC} = 12.5 Vdc, P_{out} = 4.0 W, I_C(max) = 500 mAdc, f = 470 MHz)	2N5945		60	–	–	
(V_{CC} = 12.5 Vdc, P_{out} = 10 W, I_C(max) = 1.3 Adc, f = 470 MHz)	2N5946		60	–	–	

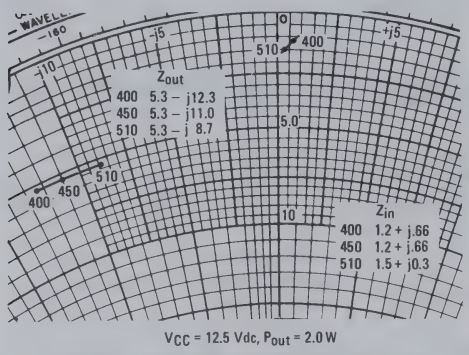
*Indicates JEDEC Registered Data

These devices are available in various packages, such as a studless stripline package, TO-39, and also in chip form on beryllium oxide carriers for hybrid assemblies.

For further information, contact your nearest Motorola representative or the factory representative.

2N5944
TYPICAL PERFORMANCE DATA

FIGURE 1 – SERIES EQUIVALENT IMPEDANCE



V_{CC} = 12.5 Vdc, P_{out} = 2.0 W

FIGURE 2 – OUTPUT POWER versus SUPPLY VOLTAGE

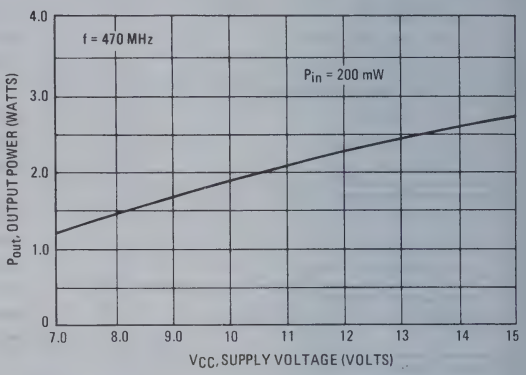


FIGURE 3 – OUTPUT POWER versus INPUT POWER

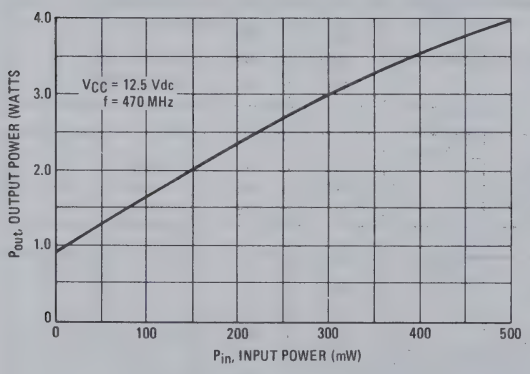


FIGURE 4 – OUTPUT POWER versus FREQUENCY

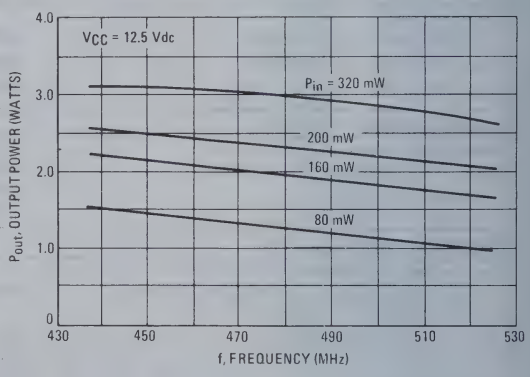


FIGURE 5 – OUTPUT POWER versus INPUT POWER

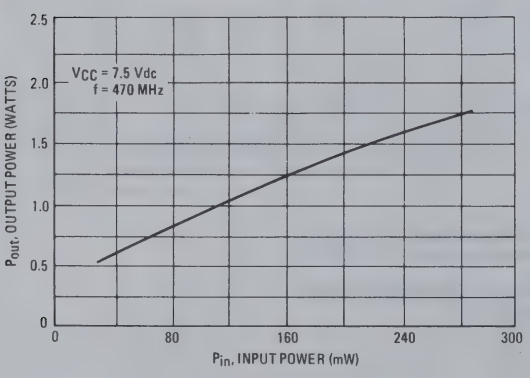
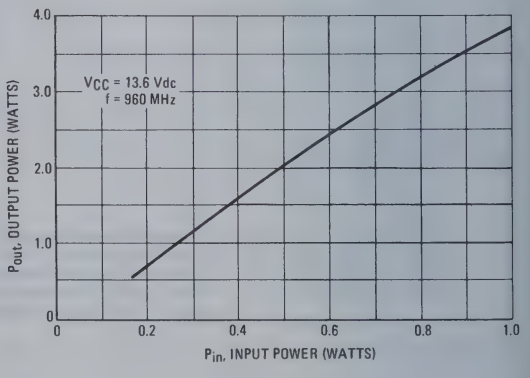
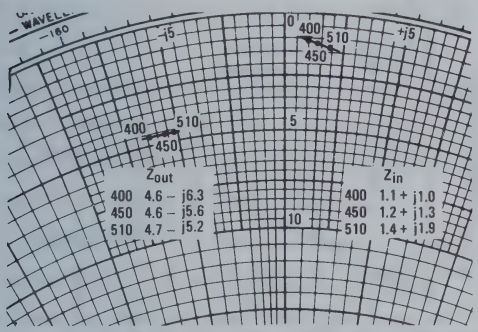


FIGURE 6 – OUTPUT POWER versus INPUT POWER



2N5945
TYPICAL PERFORMANCE DATA

FIGURE 7 – SERIES EQUIVALENT IMPEDANCE



V_{CC} = 12.5 Vdc, P_{out} = 4.0 W

FIGURE 8 – OUTPUT POWER versus SUPPLY VOLTAGE

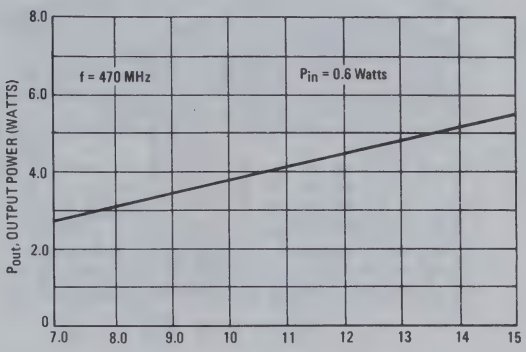


FIGURE 9 – OUTPUT POWER versus INPUT POWER

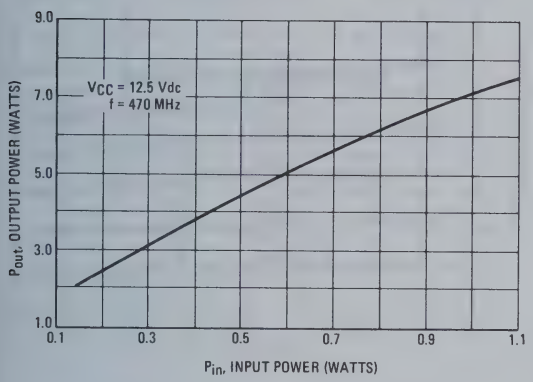


FIGURE 10 – OUTPUT POWER versus FREQUENCY

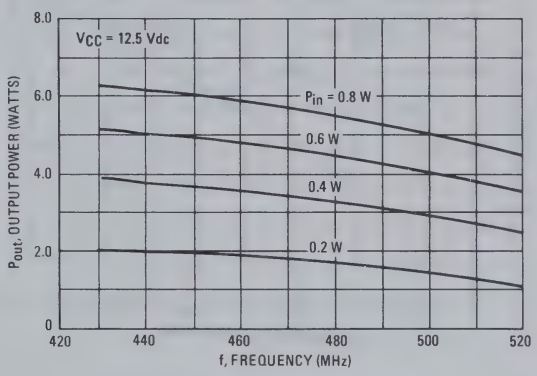


FIGURE 11 – OUTPUT POWER versus INPUT POWER

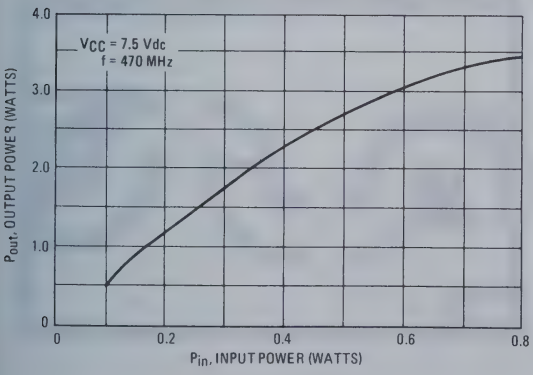
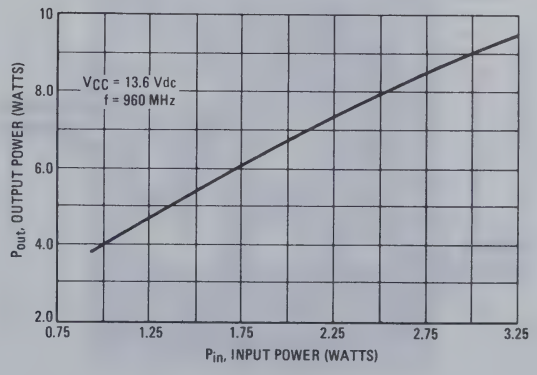
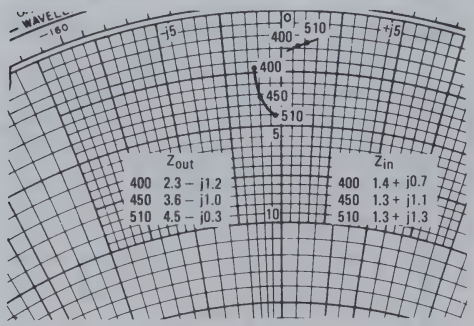


FIGURE 12 – OUTPUT POWER versus INPUT POWER



2N5946
TYPICAL PERFORMANCE DATA

FIGURE 13 – SERIES EQUIVALENT IMPEDANCE



V_{CC} = 12.5 Vdc, P_{out} = 12 W

FIGURE 14 – OUTPUT POWER versus SUPPLY VOLTAGE

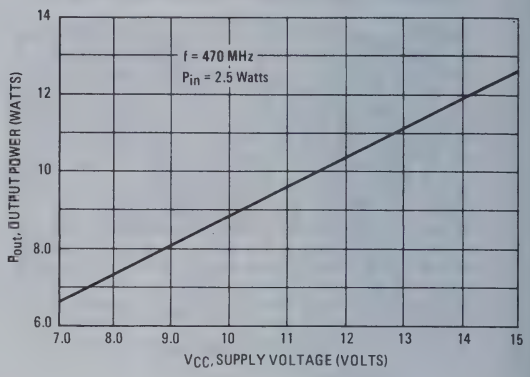


FIGURE 15 – OUTPUT POWER versus INPUT POWER

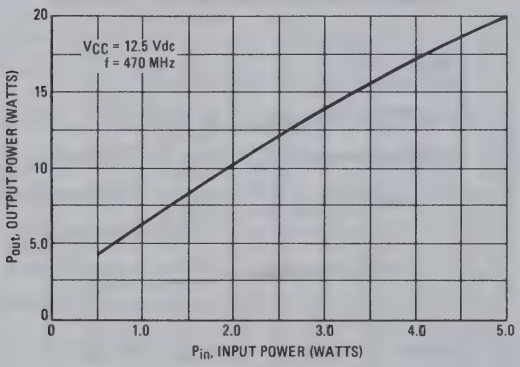


FIGURE 16 – OUTPUT POWER versus FREQUENCY

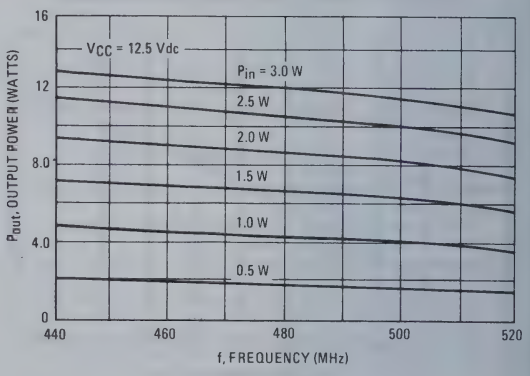


FIGURE 17 – OUTPUT POWER versus INPUT POWER

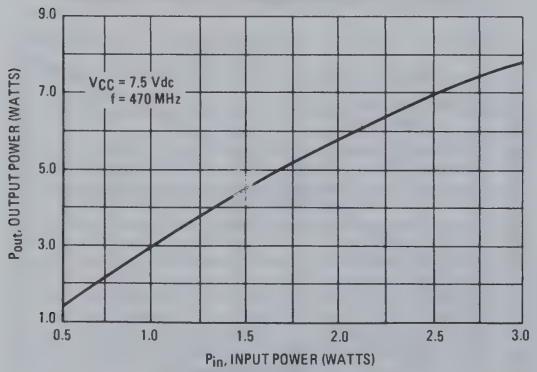
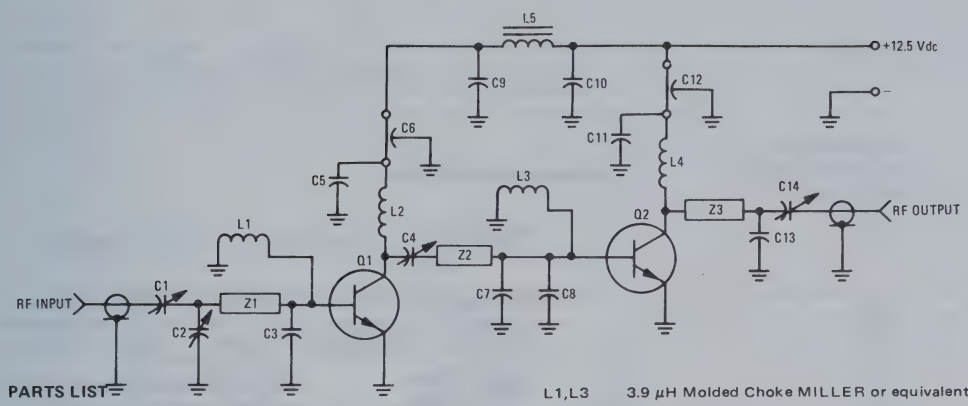


FIGURE 18



PARTS LIST

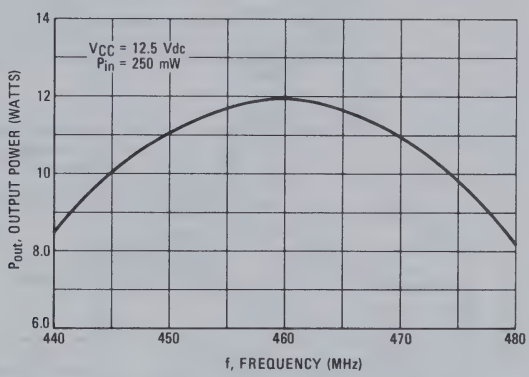
C1,C2,C4,C13,C14	0.9-7.0 pF ARCO 400 or equivalent
C3,C7,C8	25 pF UNELCO or equivalent
C5,C11	0.1 μF Ceramic 35 V
C6,C12	680 pF ALLEN BRADLEY Feedthru
C9,C10	1.0 μF, 35 V Tantalum
L1,L3	3.9 μH Molded Choke MILLER or equivalent
L2,L4	5 Turns #18 AWG Enameled 0.2" I.D.
L5	FERROXCUBE Ferrite Choke VK200 20/4B
Z1,Z2,Z3	Microstrip Lines (See Template Below)
Q1	2N5944
Q2	2N5946

10 W AMPLIFIER PERFORMANCE

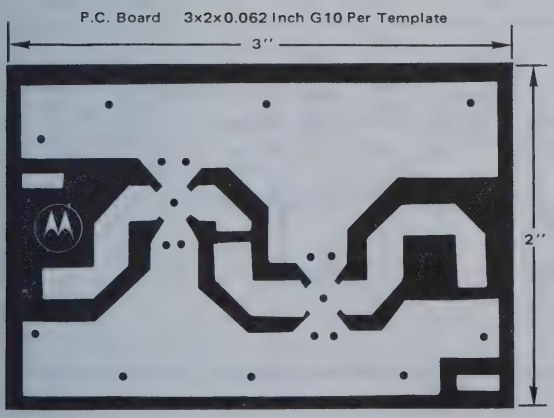
V_{CC} = 12.5 Vdc

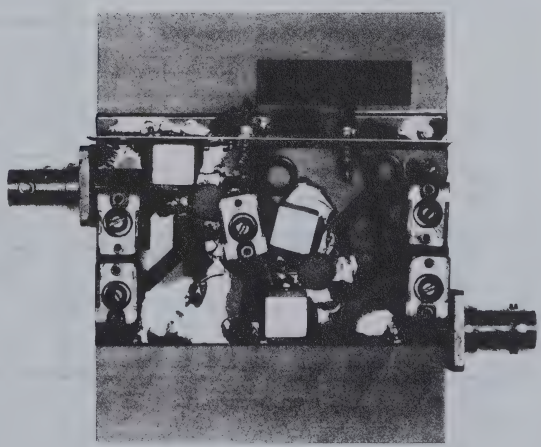
Frequency MHz	P_{in} mW	P_{out} W	I_C Amp
440	250	8.5	1.5
450	250	11	1.6
460	250	12	1.6
470	250	10.9	1.5
480	250	8.2	1.2

FIGURE 19 – OUTPUT POWER versus FREQUENCY



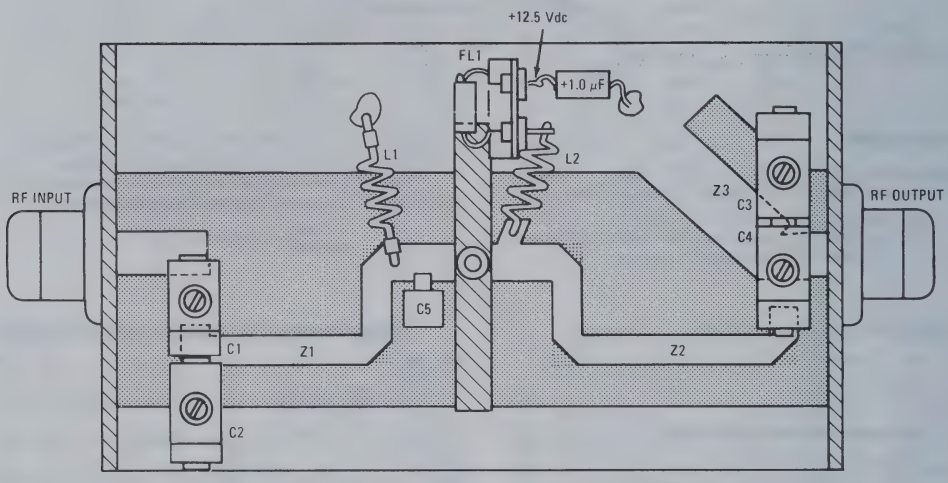
P.C. Board 3x2x0.062 Inch G10 Per Template





470 MHz TEST CIRCUIT

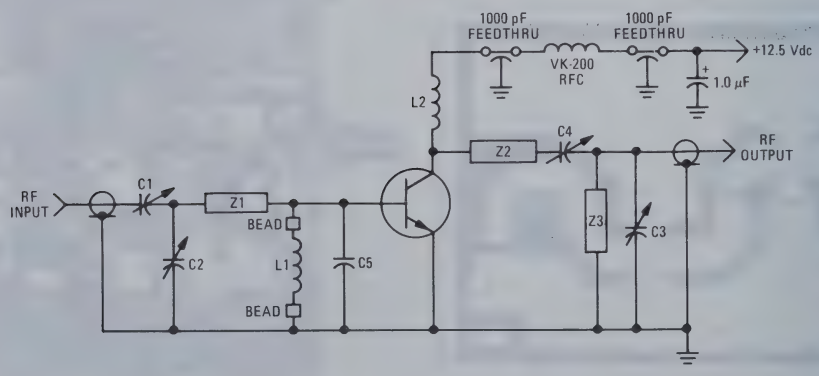
FIGURE 20



C1,2 1.0-25 pF ARCO 421 OR EQUIVALENT
C3,4 1.0-25 pF ARCO 421 OR EQUIVALENT
L1,2 7 TURNS #22 AWG, 0.2" I.D.
FERRITE BEADS FERROXCUBE 56-590-65-3B
AS SHOWN ON L1
FL1 DC SUPPLY FILTER
2-1000 pF FT CAPACITOR
1-1.0 μF, 35 V CAPACITOR
1-CHOKE FERROXCUBE VK 200-20-4B

CONNECTORS ARE TYPE "N"
BOARD IS GLASS TEFLON
3" x 5" x 0.060"
MOUNTING PLATE IS 3" x 5" x 0.75"

FIGURE 21



2N5947 (SILICON)

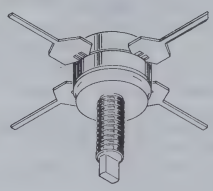
The RF Line

NPN SILICON HIGH FREQUENCY TRANSISTOR

. . . designed specifically for broadband applications requiring low cross-modulation distortion and low noise figure. Characterized for use in CATV applications. The 2N5947 was formerly the MM8012.

- Low Cross Modulation Distortion —
  XM = -57 dB (Max) @ +50 dBmV Output
- Low Noise Figure — @ f = 200 MHz
  NF (Narrowband) = 3.8 dB (Typ)
  NF (Broadband) = 8.5 dB (Max)
- High Broadband Power Gain —
  G_{pe} = 10 dB (Min) @ f = 250 MHz

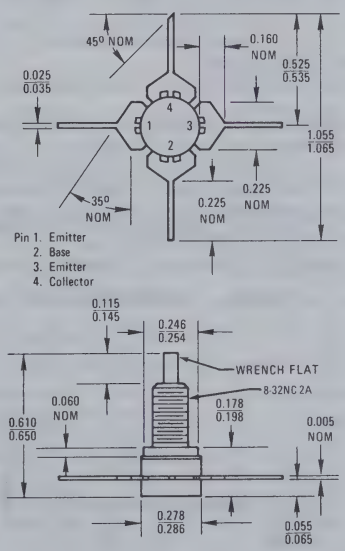
NPN SILICON
HIGH FREQUENCY
TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 144D-01 (1)

2N5947 (continued)

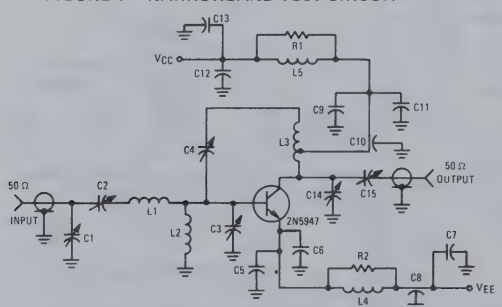
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 75 mAdc, V_{CE} = 20 Vdc)	h_{FE}	25	–	250	–
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	0.2	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{BE(sat)}$	–	1.0	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (Figure 3) (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1100	1500	–	MHz
Collector-Base Capacitance (Figure 4) (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	1.5	4.0	pF
Emitter-Base Capacitance (Figure 4) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	8.2	12	pF
Small-Signal Current Gain (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)	h_{fe}	25	–	300	–
Collector-Base Time Constant (I_E = 75 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	$r_b'C_c$	2.0	–	20	ps
Noise Figure	NF				dB
(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz) (Figure 1)		–	3.8	–	
(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz) (1) (Figure 2, 9)		–	7.2	8.5	
(I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz) (1) (Figure 2, 9)		–	7.8	–	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 2) (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 250 MHz)	G_{pe}	10	11	–	dB
Intermodulation Distortion (Figure 2, 10) (I_C = 75 mAdc, V_{CE} = 20 Vdc, V_{out} = +50 dBmv)	IM	–	-55	-50	dB
Cross Modulation Distortion (Figure 2, 11) (I_C = 75 mAdc, V_{CE} = 20 Vdc, V_{out} = +50 dBmV)	XM	–	-60	-57	dB

*Indicates JEDEC Registered Data.

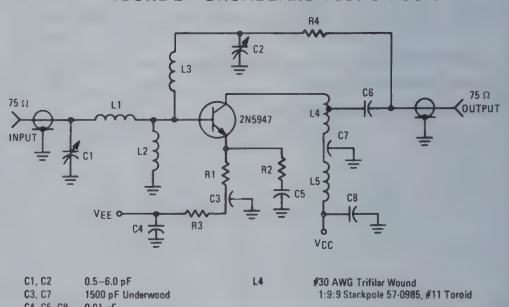
(1) Includes noise figure of post-amplifier and matching pad.

FIGURE 1 – NARROWBAND TEST CIRCUIT



C1, C2, C3	1.0–20 pF	L2	1-1/2 Turns AWG #18, 1/4" I.D., 3/16" Long
C4, C14, C15	1.0–10 pF	L3	9-3/4 Turns AWG #18, 3/16" I.D., 1" Long Tapped 1-3/4 Turns from Collector End
C5, C8, C9	470 pF		
C6, C10, C11	0.001 μF		
C7, C13	0.01 μF		
C12	0.1 μF		
L1	3 Turns AWG #18, 1/4" I.D., 5/16" Long	L4, L5	0.47 μH Molded Choke
		R1, R2	10 Ohms

FIGURE 2 – BROADBAND TEST CIRCUIT



C1, C2	0.5–6.0 pF	L4	#30 AWG Trifilar Wound 1:9:9 Stackpole 57-0985, #11 Toroid
C3, C7	1500 pF Underwood		
C4, C5, C8	0.01 μF		
C6	470 pF	L5	Ferrite Choke, 3 Turns #30 on Stackpole 57-0156 Bead
L1	3 Turns #20 AWG, 5/32" I.D.	R1	20 Ohms
L2	0.84 μH, Ohmite Z235	R2	68 Ohms
L3	5 Turns #26 AWG, 5/32" I.D.	R3	150 Ohms
		R4	360 Ohms

FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

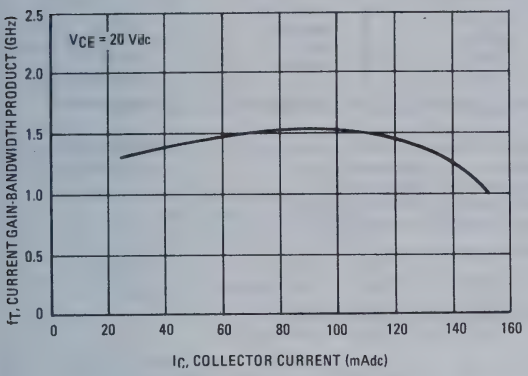


FIGURE 4 – CAPACITANCES

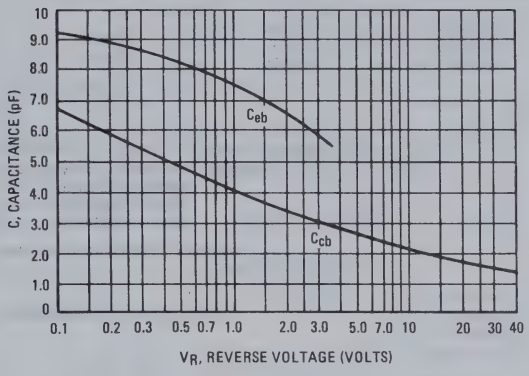


FIGURE 5 – COLLECTOR-EMITTER SATURATION VOLTAGE

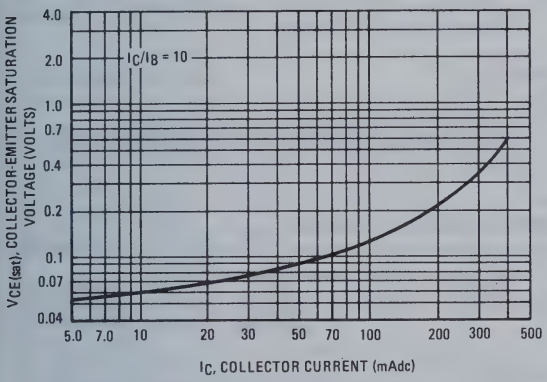


FIGURE 6 – BASE-EMITTER SATURATION VOLTAGE

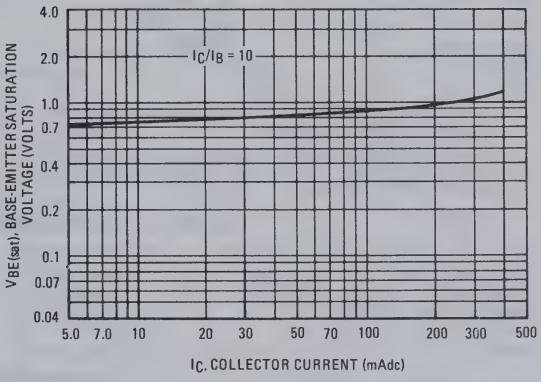


FIGURE 7 – NARROWBAND NOISE FIGURE versus CURRENT

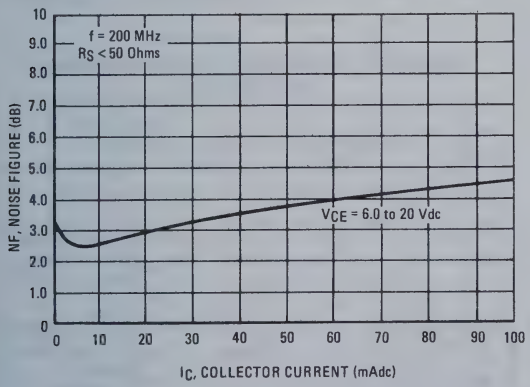


FIGURE 8 – BROADBAND NOISE FIGURE versus CURRENT

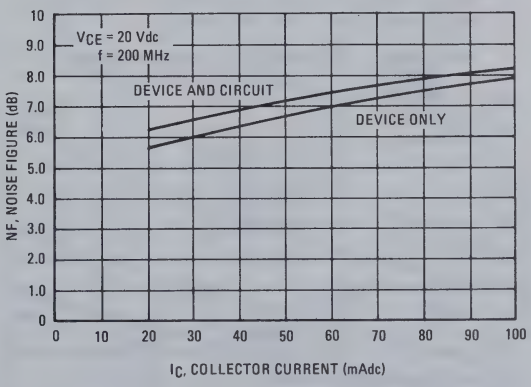
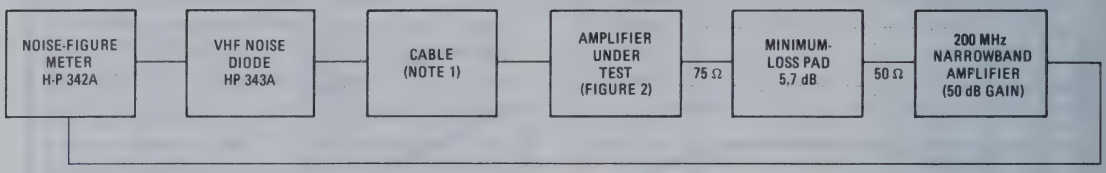


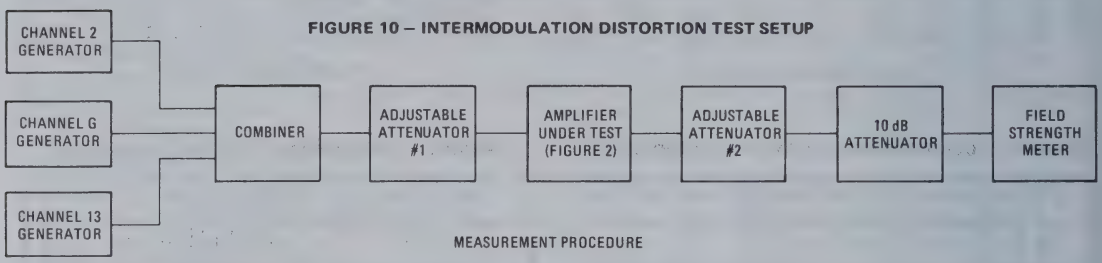
FIGURE 9 – NOISE FIGURE TEST SETUP



NOTE 1. RG-59 CABLE WITH ORIGINAL CENTER CONDUCTOR REPLACED WITH #30 WIRE. OVERALL LENGTH, INCLUDING BNC CONNECTORS, IS A QUARTER-WAVELENGTH AT 200 MHz (APPROX. 11 INCHES). USED TO MATCH IMPEDANCE OF NOISE DIODE TO AMPLIFIER UNDER TEST.

THE NOISE FIGURE OF THE POST-AMPLIFIERS AND MINIMUM LOSS PAD IS 8.4 dB.

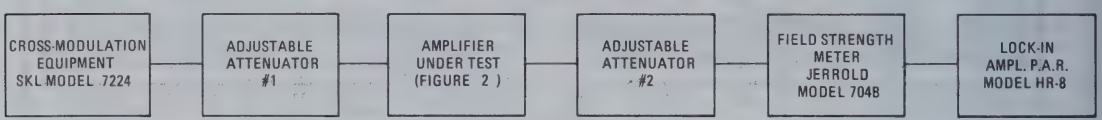
FIGURE 10 – INTERMODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST CHANNEL 2 GENERATOR FOR RATED OUTPUT FROM TEST AMPLIFIER (CHANNELS G & 13 OFF).
2. REPEAT FOR CHANNEL G (2 & 13 OFF) AND CHANNEL 13 (2 & G OFF). NOTE FOR REFERENCE THE FIELD STRENGTH METER READING FOR CHANNEL 13 (2 & G OFF).
3. TURN CHANNEL 13 OFF AND DRIVE THE TEST AMPLIFIER WITH CHANNELS 2 & G. MEASURE THE LEVEL OF INTERMODULATION DISTORTION AT CHANNEL 13 RELATIVE TO THE REFERENCE LEVEL IN STEP 2.

FIGURE 11 – CROSS MODULATION DISTORTION TEST SETUP



MEASUREMENT PROCEDURE

1. ADJUST THE CROSSMODULATION EQUIPMENT FOR +50 dBmV OUTPUT FROM EACH CHANNEL.
2. ADJUST ATTENUATOR #1 FOR THE DESIRED OUTPUT LEVEL FROM THE TEST AMPLIFIER. ADJUST ATTENUATOR #2 TO MAINTAIN THE FIELD STRENGTH METER INPUT AT +10 dBmV.
3. WITH THE FIELD STRENGTH METER SELECT CHANNEL 13. USING THE WAVE ANALYZER MEASURE THE LEVEL OF THE MODULATION ON CHANNEL 13 DUE TO CROSS-MODULATION OF CHANNELS 2-12.

FIGURE 12 – CROSS MODULATION DISTORTION versus OUTPUT LEVEL

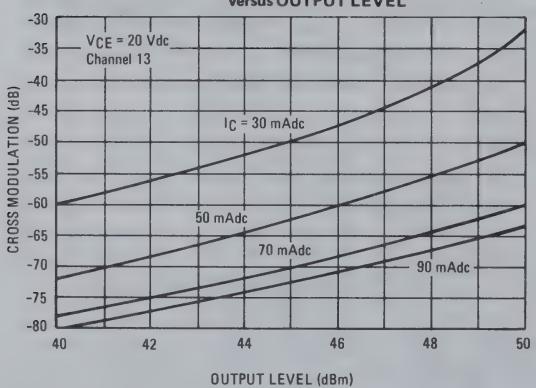
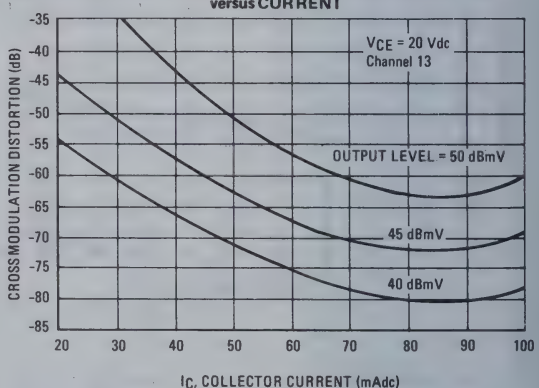


FIGURE 13 – CROSS MODULATION DISTORTION versus CURRENT



2N5974 2N5975 2N5976 (SILICON)
MJE5974 MJE5975 MJE5976

PNP SILICON PLASTIC POWER TRANSISTORS

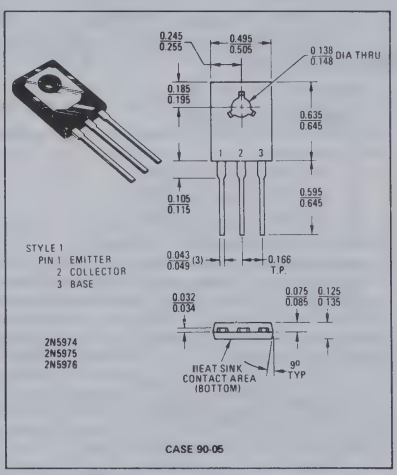
. . . designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 5 Amperes
  h_{FE} = 20-120 @ I_C = 2.5 Adc
  = 7.0 (Min) @ I_C = 5.0 Adc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N5974, MJE5974
  = 60 Vdc (Min) – 2N5975, MJE5975
  = 80 Vdc (Min) – 2N5976, MJE5976
- High Current Gain – Bandwidth Product –
  f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Complements to NPN Transistors 2N5977, 2N5978, 2N5979 and MJE5977, MJE5978, MJE5979
- Choice of Packages – 2N5974 Series – Case 90
  MJE5974 Series – Case 199

5 AMPERE
POWER TRANSISTORS

PNP SILICON

40-60-80 VOLTS
75 WATTS



CASE 90-05

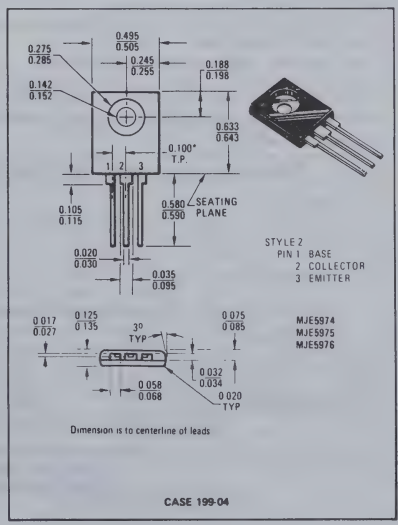
*MAXIMUM RATINGS

Rating	Symbol	2N5974 MJE5974	2N5975 MJE5975	2N5976 MJE5976	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous Peak	I_C	5.0 10			Adc
Base Current	I_B	2.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	75 0.60			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

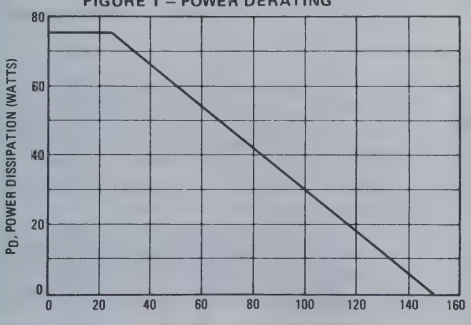
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.67	°C/W

*Indicates JEDEC Registered Data for 2N5974 Series.



CASE 199-04

FIGURE 1 – POWER DERATING



***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

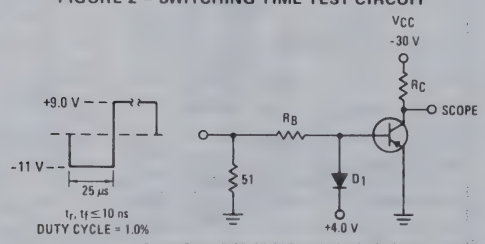
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N5974, MJE5974		40	–	
	2N5975, MJE5975		60	–	
	2N5976, MJE5976		80		
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N5974, MJE5974		–	1.0	
(V_{CE} = 30 Vdc, I_B = 0)	2N5975, MJE5975		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5976, MJE5976		–	1.0	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5974, MJE5974		–	100	μAdc
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5975, MJE5975		–	100	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5976, MJE5976		–	100	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5974, MJE5974		–	1.0	mAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5975, MJE5975		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5976, MJE5976		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			40	–	
(I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)			20	120	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			7.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.5 Adc, I_B = 250 mAdc			–	0.6	
(I_C = 5.0 Adc, I_B = 750 mAdc			–	1.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 5.0 Adc, I_B = 750 mAdc)			–	2.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)			–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			2.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	300	
Small-Signal Current Gain		h_{fe}			–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)			20	–	

*Indicates JEDEC Registered Data for 2N5974 Series.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

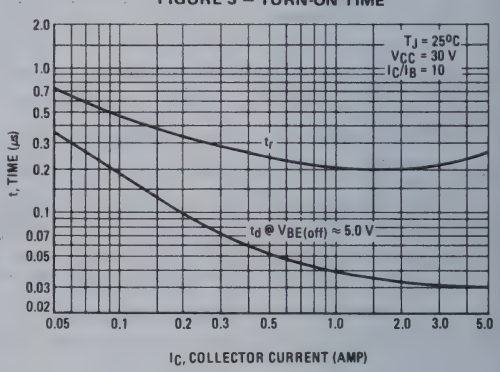


FIGURE 4 – THERMAL RESPONSE

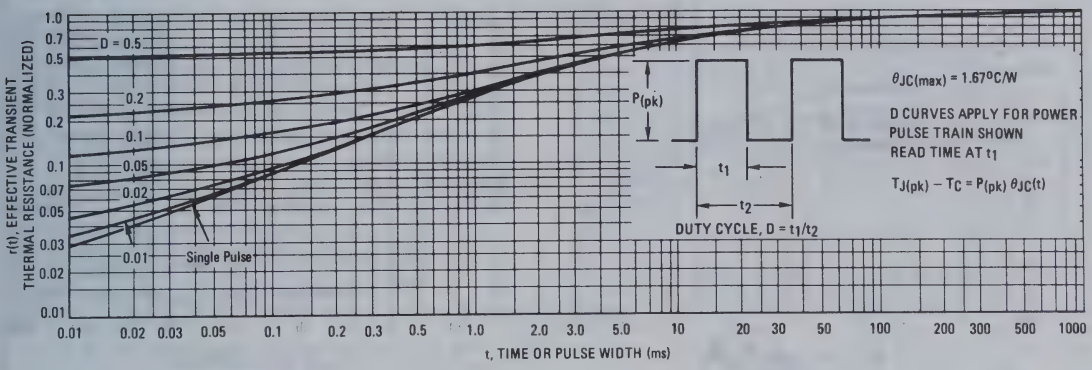
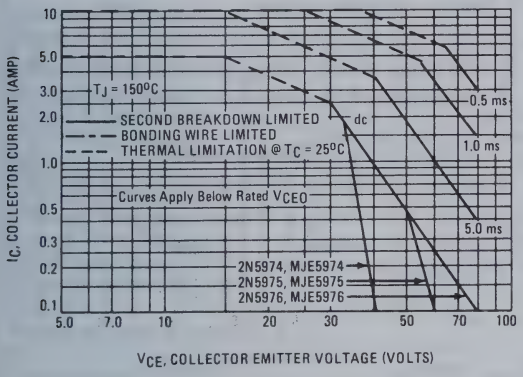


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

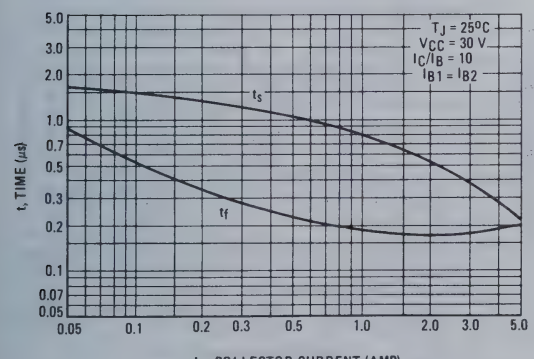


FIGURE 7 – CAPACITANCE

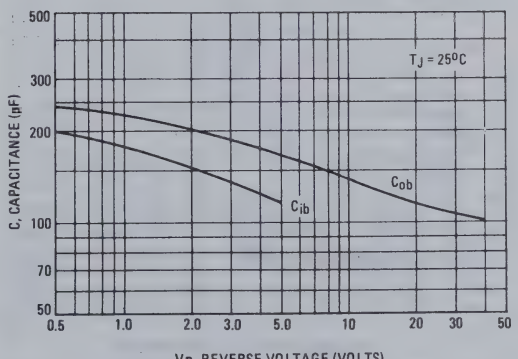


FIGURE 8 – DC CURRENT GAIN

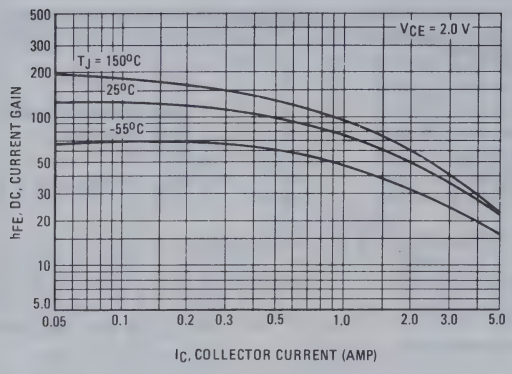


FIGURE 9 – COLLECTOR SATURATION REGION

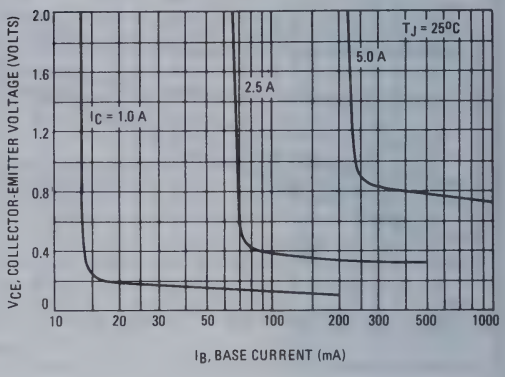


FIGURE 10 – "ON" VOLTAGES

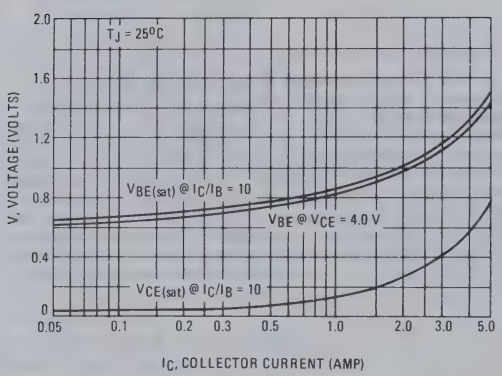


FIGURE 11 – TEMPERATURE COEFFICIENTS

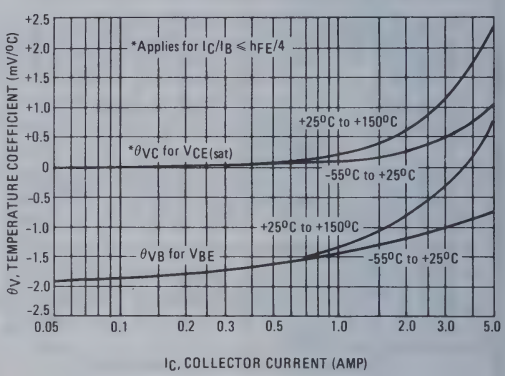


FIGURE 12 – COLLECTOR CUT-OFF REGION

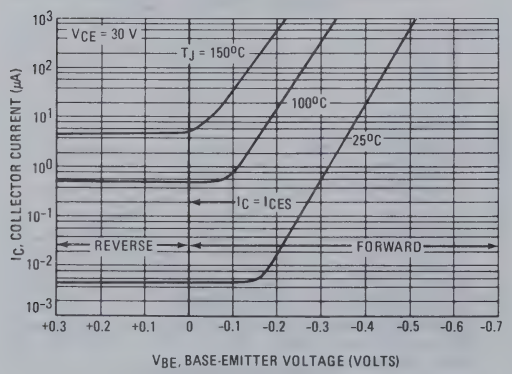
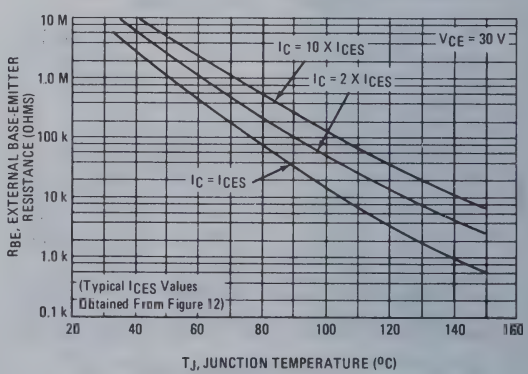


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5977 2N5978 2N5979 (SILICON)
MJE5977 MJE5978 MJE5979

NPN SILICON PLASTIC POWER TRANSISTORS

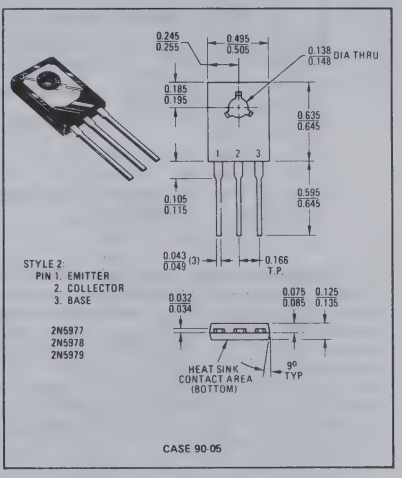
. . . designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 5 Amperes
  h_{FE} = 20-120 @ I_C = 2.5 Adc
  = 7.0 (Min) @ I_C = 5.0 Adc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N5977, MJE5977
  = 60 Vdc (Min) – 2N5978, MJE5978
  = 80 Vdc (Min) – 2N5979, MJE5979
- High Current Gain – Bandwidth Product
  f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Complement to PNP Transistors –
  2N5974, 2N5975, 2N5976 and MJE5974, MJE5975, MJE5976
- Choice of Packages – 2N5977 Series – Case 90
  MJE5977 Series – Case 199

5 AMPERE
POWER TRANSISTORS

NPN SILICON

40-60-80 VOLTS
75 WATTS



CASE 90-05

*MAXIMUM RATINGS

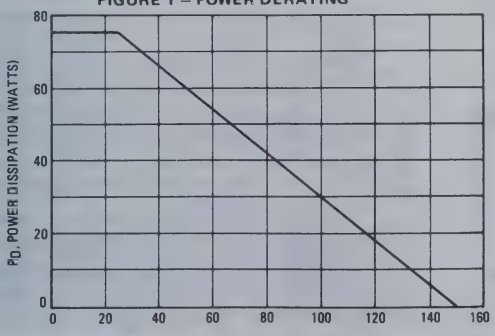
Rating	Symbol	2N5977 MJE5977	2N5978 MJE5978	2N5979 MJE5979	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	5.0			Adc
Peak		10			
Base Current	I_B	2.0			Adc
Total Device Dissipation @ T_C = 25°C	P_D	75			Watts
Derate above 25°C		0.60			W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150			°C

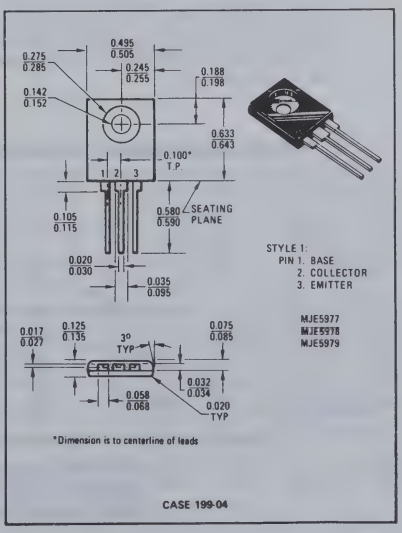
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.67	°C/W

*Indicates JEDEC Registered Data for 2N5977 Series.

FIGURE 1 – POWER DERATING





CASE 199-04

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

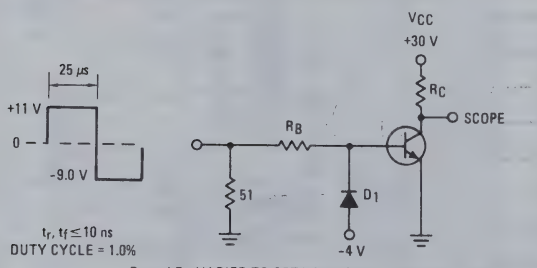
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N5977, MJE5977		40	–	
	2N5978, MJE5978		60	–	
	2N5979, MJE5979		80		
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N5977, MJE5977		–	1.0	
(V_{CE} = 30 Vdc, I_B = 0)	2N5978, MJE5978		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5979, MJE5979		–	1.0	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5977, MJE5977		–	100	μAdc
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5978, MJE5978		–	100	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5979, MJE5979		–	100	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5977, MJE5977		–	1.0	mAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5978, MJE5978		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5979, MJE5979		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			40	–	
(I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)			20	120	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			7.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.5 Adc, I_B = 250 mAdc)			–	0.6	
(I_C = 5.0 Adc, I_B = 750 mAdc)			–	1.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 5.0 Adc, I_B = 750 mAdc)			–	2.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)			–	1.4	
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			2.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	200	
Small-Signal Current Gain		h_{fe}			–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)			20	–	

*Indicates JEDEC Registered Data for 2N5977 Series.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

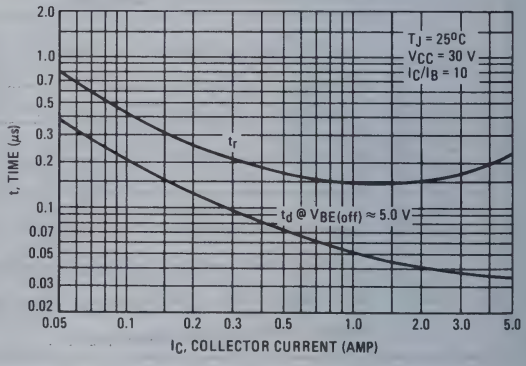


FIGURE 4 – THERMAL RESPONSE

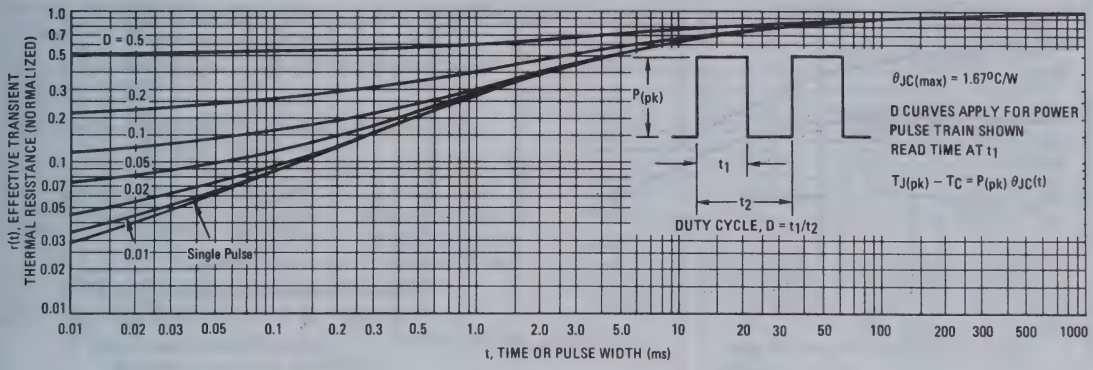
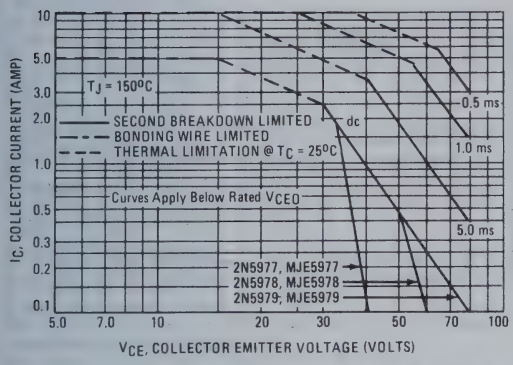


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

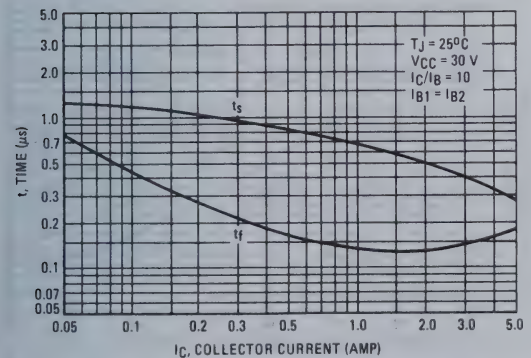


FIGURE 7 – CAPACITANCE

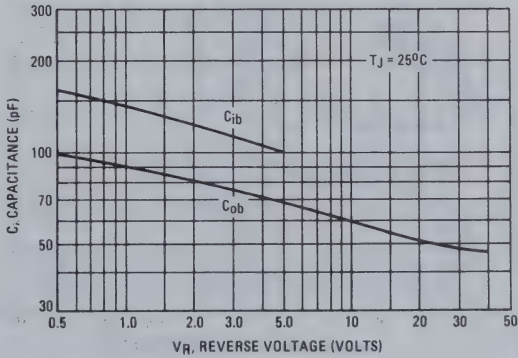


FIGURE 8 – DC CURRENT GAIN

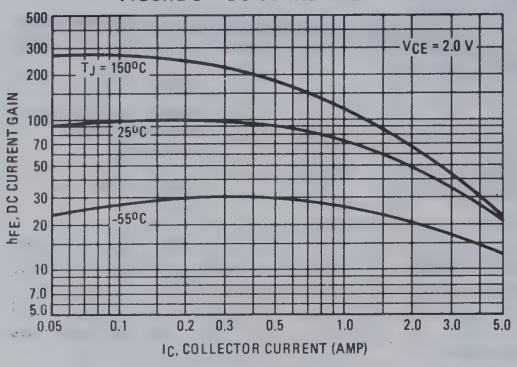


FIGURE 9 – COLLECTOR SATURATION REGION

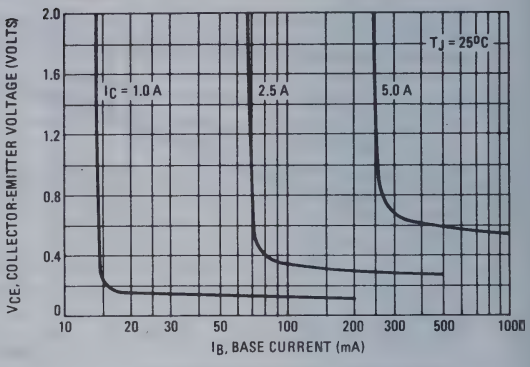


FIGURE 10 – "ON" VOLTAGES

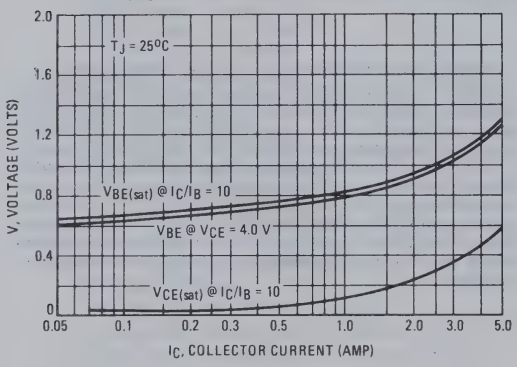


FIGURE 11 – TEMPERATURE COEFFICIENTS

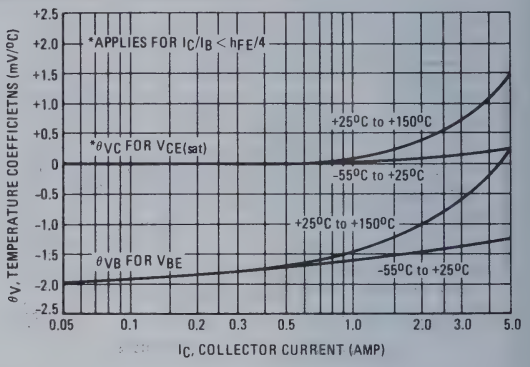


FIGURE 12 – COLLECTOR CUT-OFF REGION

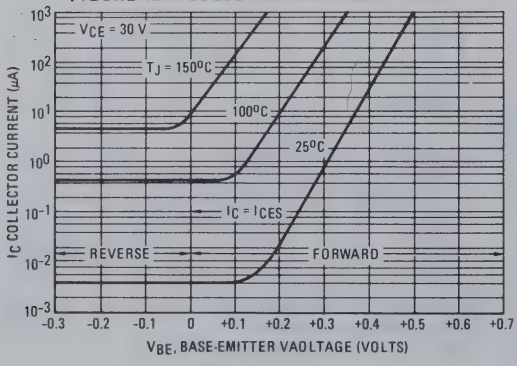
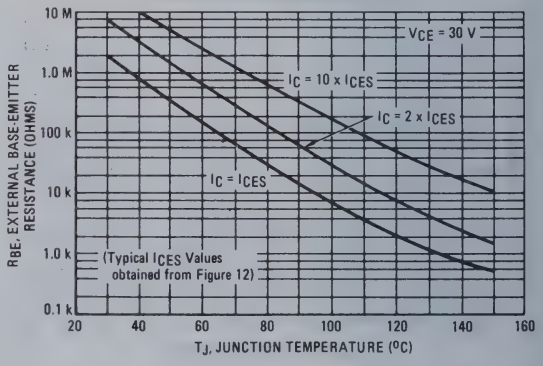


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5980 2N5981 2N5982 (SILICON)
MJE5980 MJE5981 MJE5982

HIGH POWER PNP SILICON TRANSISTORS

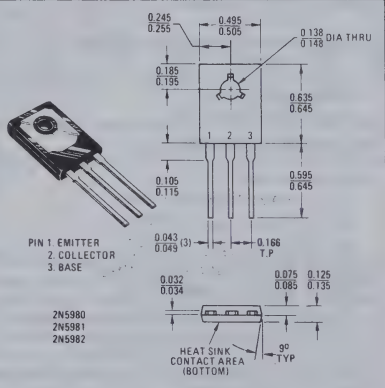
. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 8 Amperes –
  h_{FE} = 20-120 @ I_C = 4.0 Adc
  = 7.0 (Min) @ I_C = 8.0 Adc
- Collector-Emitter Sustaining Voltage
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N5980, MJE5980
  = 60 Vdc (Min) – 2N5981, MJE5981
  = 80 Vdc (Min) – 2N5982, MJE5982
- High Current Gain – Bandwidth Product –
  f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Complements to NPN Transistors – 2N5983, 2N5984, 2N5985 and MJE5983, MJE5984, MJE5985
- Choice of Packages – 2N5980 Series – Case 90
  MJE5980 Series – Case 199

8 AMPERE POWER TRANSISTORS

PNP SILICON

40-60-80 VOLTS
90 WATTS



CASE 90-05

*MAXIMUM RATINGS

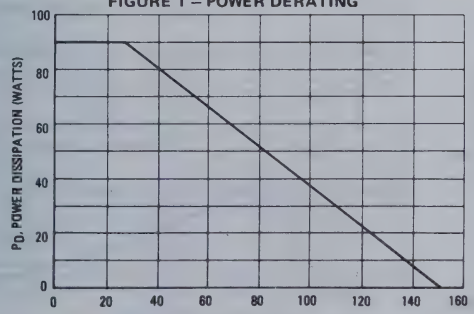
Rating	Symbol	2N5980 MJE5980	2N5981 MJE5981	2N5982 MJE5982	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous Peak	I_C	8.0 15			Adc
Base Current	I_B	3.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	90 0.72			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

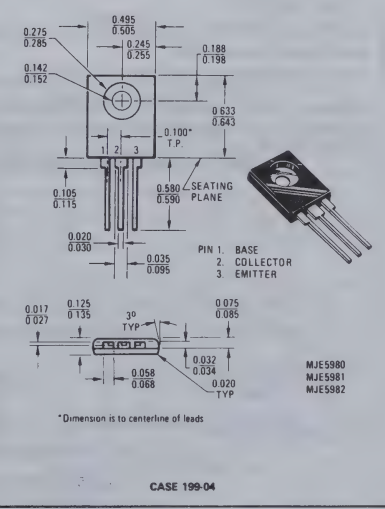
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

*Indicates JEDEC Registered Data for 2N5980 Series.

FIGURE 1 – POWER DERATING





CASE 199-04

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

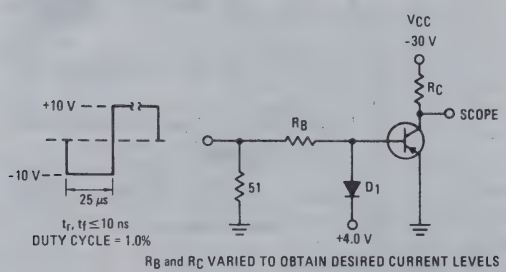
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5980, MJE5980		40	–	
	2N5981, MJE5981		60	–	
	2N5982, MJE5982		80	–	
Collector Cutoff Current		I_{CEO}			mA
(V_{CE} = 20 Vdc, I_B = 0)	2N5980, MJE5980		–	1.0	
(V_{CE} = 30 Vdc, I_B = 0)	2N5981, MJE5981		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5982, MJE5982		–	1.0	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5980, MJE5980		–	100	μAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5981, MJE5981		–	100	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5982, MJE5982		–	100	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5980, MJE5980		–	1.0	mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5981, MJE5981		–	1.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5982, MJE5982		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			40	–	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)			20	120	
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)			7.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 400 mAdc)			–	0.6	
(I_C = 8.0 Adc, I_B = 1.2 Adc)			–	1.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 1.2 Adc)			–	2.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)			–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			2.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	350	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)			20	–	

*Indicates JEDEC Registered Data for 2N5980 Series.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

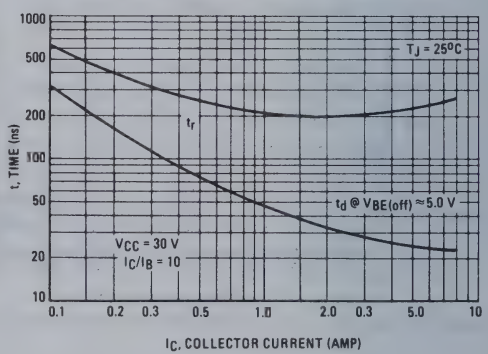


FIGURE 4 – THERMAL RESPONSE

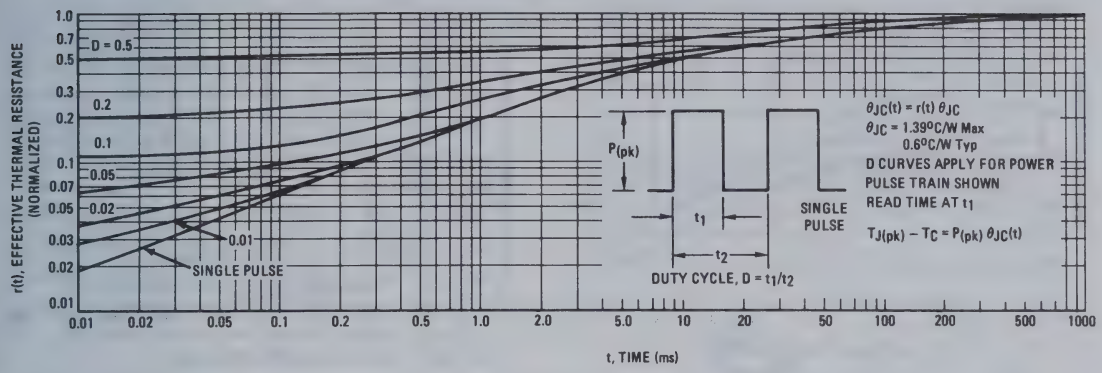
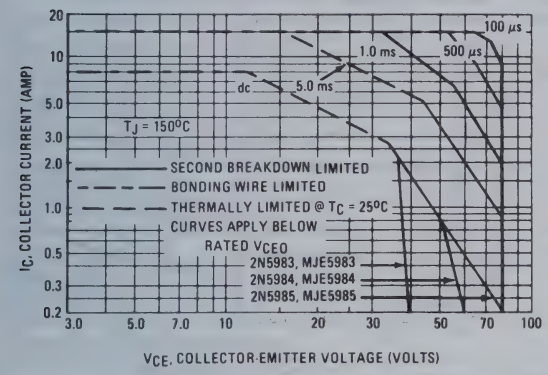


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

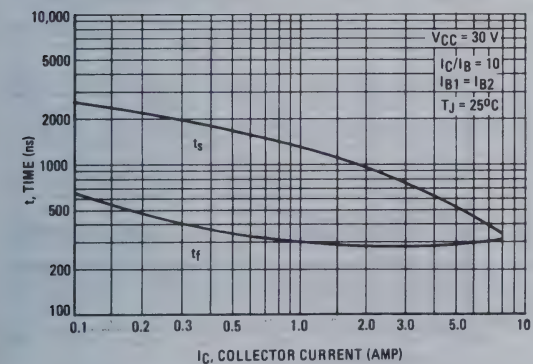


FIGURE 7 – CAPACITANCE

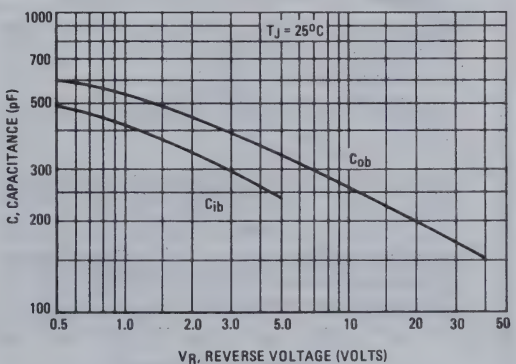


FIGURE 8 – DC CURRENT GAIN

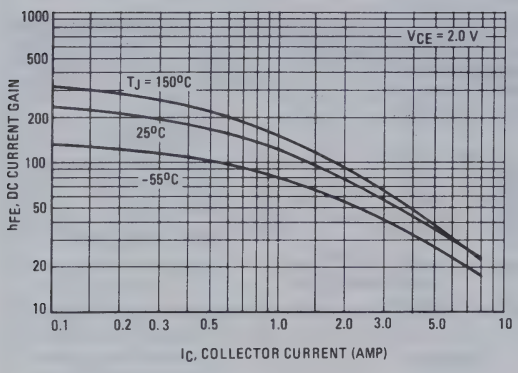


FIGURE 9 – COLLECTOR SATURATION REGION

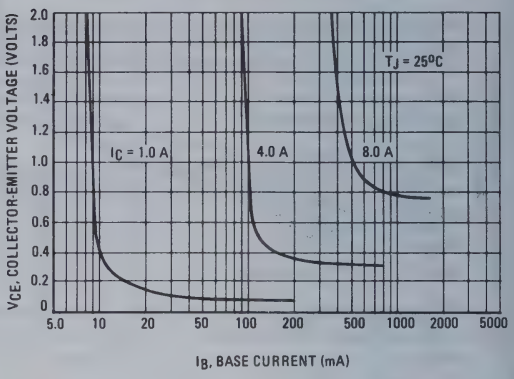


FIGURE 10 – "ON" VOLTAGES

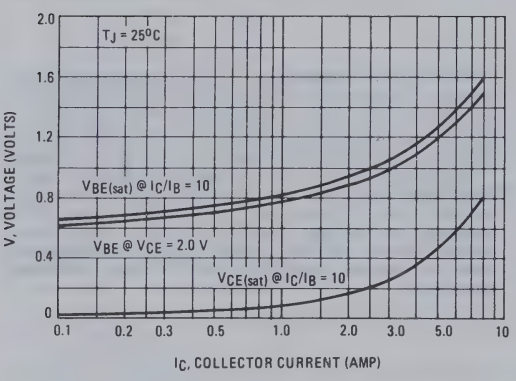


FIGURE 11 – TEMPERATURE COEFFICIENTS

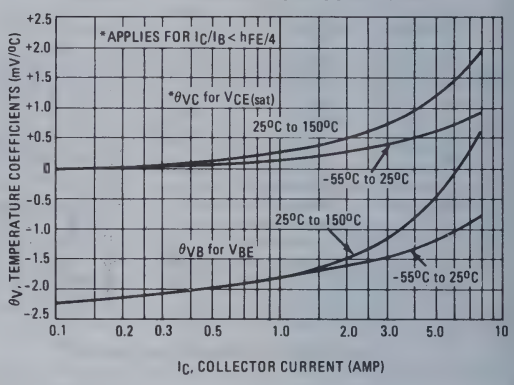


FIGURE 12 – COLLECTOR CUTOFF REGION

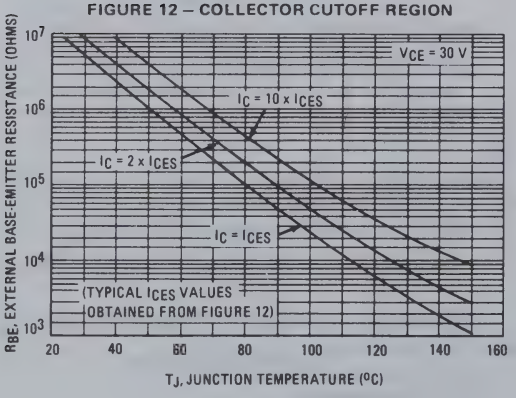
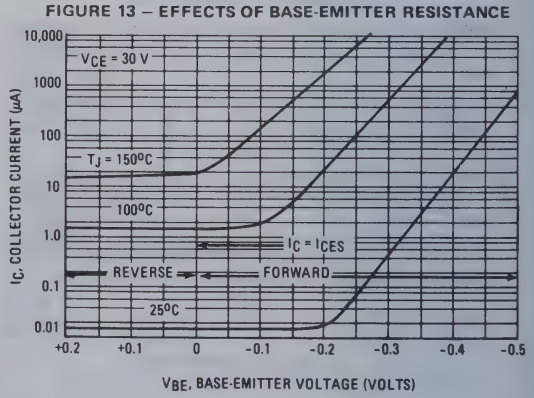


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5983 2N5984 2N5985 (SILICON)
MJE5983 MJE5984 MJE5985

HIGH POWER NPN SILICON TRANSISTORS

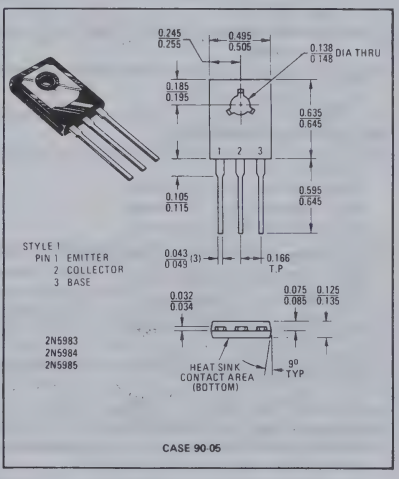
. . . designed for use in general purpose amplifier and switching applications.

- DC Current Gain Specified to 8 Amperes
  h_{FE} = 20-120 @ I_C = 4.0 Adc
  = 7.0 (Min) @ I_C = 8.0 Adc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N5983, MJE5983
  = 60 Vdc (Min) – 2N5984, MJE5984
  = 80 Vdc (Min) – 2N5985, MJE5985
- High Current Gain – Bandwidth Product –
  f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Complements to PNP Transistors –
  2N5980, 2N5981, 2N5982 and MJE5980, MJE5981, MJE5982
- Choice of Packages – 2N5983 Series – Case 90
  MJE5983 Series – Case 199

8 AMPERE
POWER TRANSISTORS

NPN SILICON

40-60-80 VOLTS
90 WATTS



CASE 90-05

***MAXIMUM RATINGS**

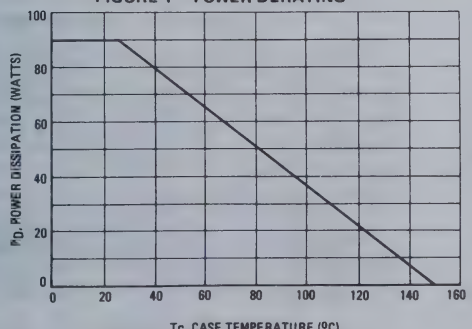
Rating	Symbol	2N5983 MJE5983	2N5984 MJE5984	2N5985 MJE5985	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	8.0			Adc
Peak		15			
Base Current	I_B	3.0			Adc
Total Device Dissipation @ T_C = 25°C	P_D	90			Watts
Derate above 25°C		0.72			W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150			°C

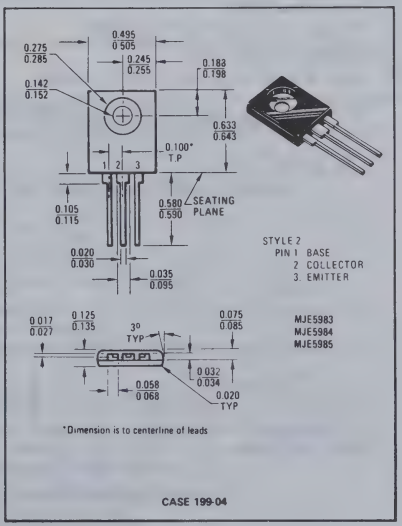
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

*Indicates JEDEC Registered Data for 2N5983 Series.

FIGURE 1 – POWER DERATING





CASE 199-04

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

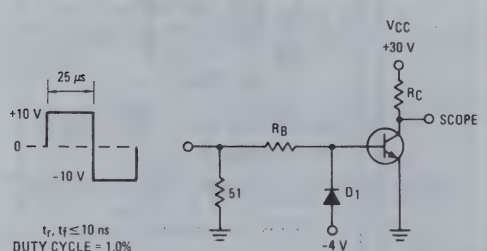
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5983, MJE5983		40	–	
	2N5984, MJE5984		60	–	
	2N5985, MJE5985		80		
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N5983, MJE5983		–	1.0	
(V_{CE} = 30 Vdc, I_B = 0)	2N5984, MJE5984		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5985, MJE5985		–	1.0	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5983, MJE5983		–	100	μAdc
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5984, MJE5984		–	100	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5985, MJE5985		–	100	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5983, MJE5983		–	1.0	mAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5984, MJE5984		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5985, MJE5985		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			40	–	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)			20	120	
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)			7.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 400 mAdc)			–	0.6	
(I_C = 8.0 Adc, I_B = 1.2 Adc)			–	1.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 1.2 Adc)			–	2.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)			–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			2.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	250	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)			20	–	

*Indicates JEDEC Registered Data for 2N5983 Series.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FIGURE 3 – TURN-ON TIME

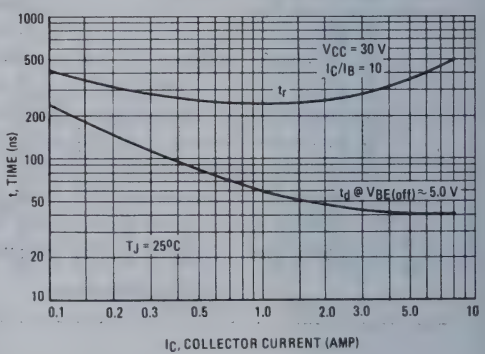


FIGURE 4 – THERMAL RESPONSE

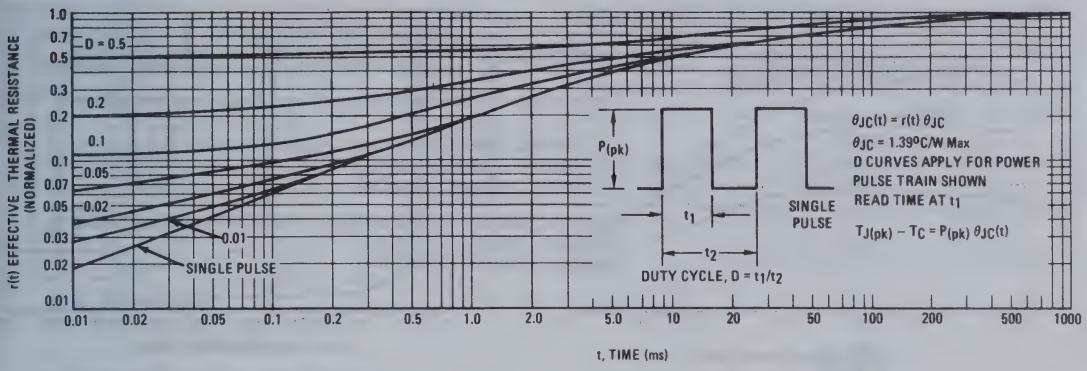
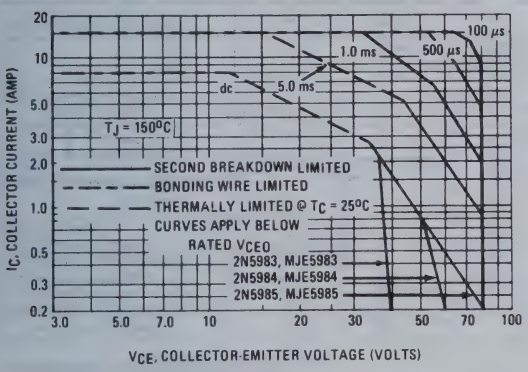


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

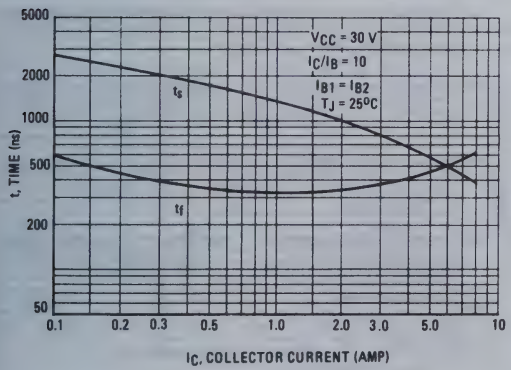


FIGURE 7 – CAPACITANCES

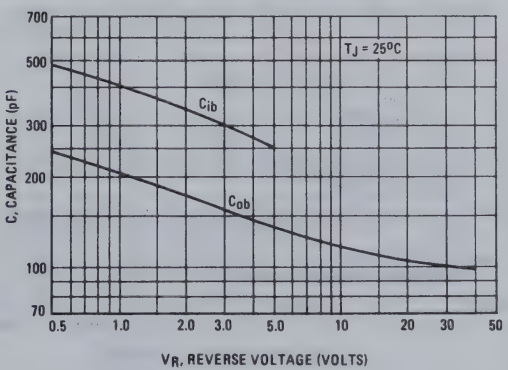


FIGURE 8 – DC CURRENT GAIN

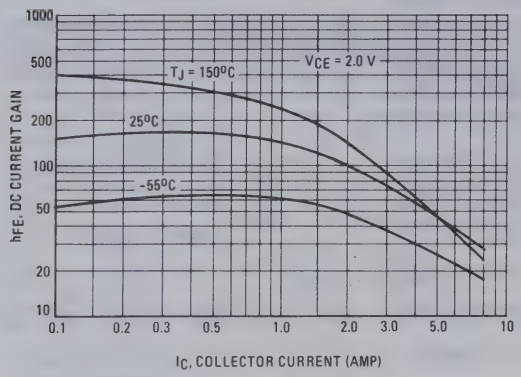


FIGURE 9 – COLLECTOR SATURATION REGION

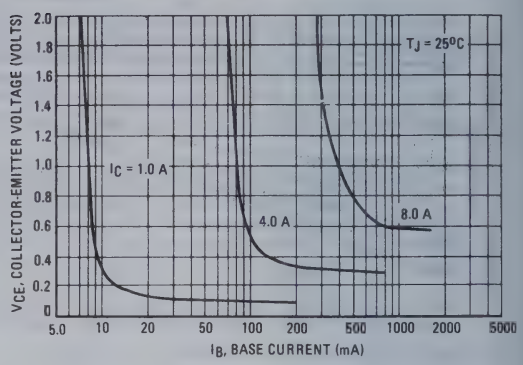


FIGURE 10 – "ON" VOLTAGES

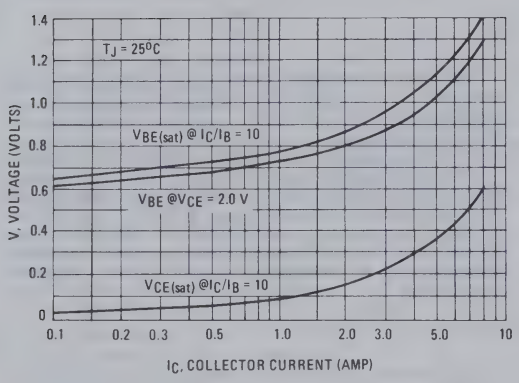


FIGURE 11 – TEMPERATURE COEFFICIENTS

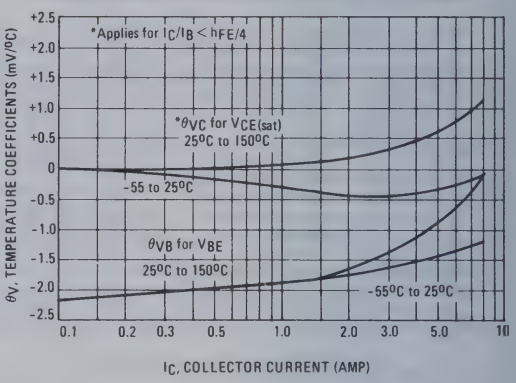


FIGURE 12 – COLLECTOR CUT-OFF REGION

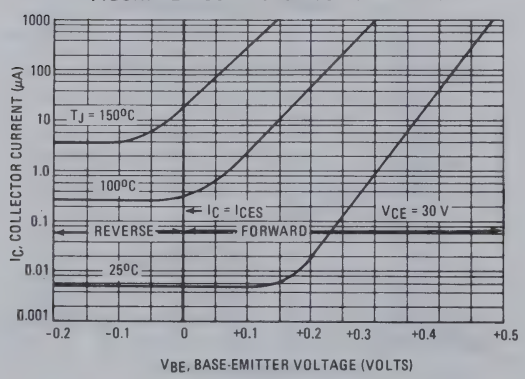
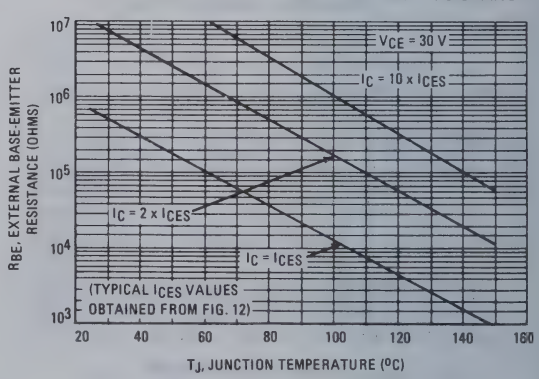


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N5986 2N5987 2N5988 PNP (SILICON)
2N5989 2N5990 2N5991 NPN

HIGH POWER PLASTIC COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for use in general-purpose amplifier and switching circuits.

- Collector-Base Voltage — V_{CBO} = 60 Vdc — 2N5986, 2N5989
  = 80 Vdc — 2N5987, 2N5990
  = 100 Vdc — 2N5988, 2N5991
- Collector-Emitter Voltage — V_{CEO} = 40 Vdc — 2N5986, 2N5989
  = 60 Vdc — 2N5987, 2N5990
  = 80 Vdc — 2N5988, 2N5991
- DC Current Gain —
  h_{FE} = 20-120 @ I_C = 6.0 Adc
  = 7.0 (Min) @ I_C = 12 Adc
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 6.0 Adc

12 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

40, 60, 80 VOLTS
100 WATTS



*MAXIMUM RATINGS

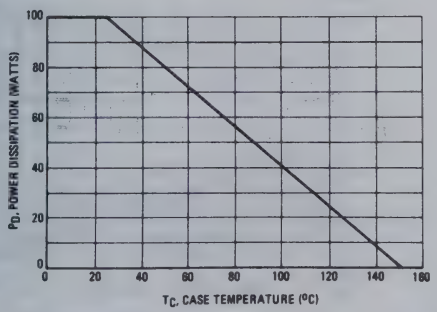
Rating	Symbol	2N5986 2N5989	2N5987 2N5990	2N5988 2N5991	Unit
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous Peak	I_C	12 20			Adc
Base Current	I_B	4.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.8			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

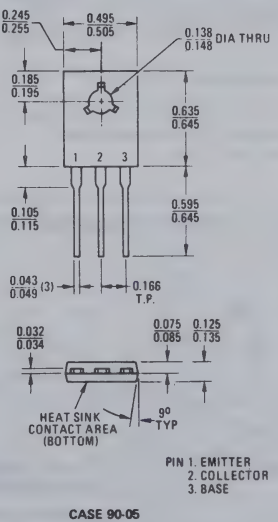
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 — POWER DERATING





PIN 1. EMITTER
2. COLLECTOR
3. BASE

CASE 90-05

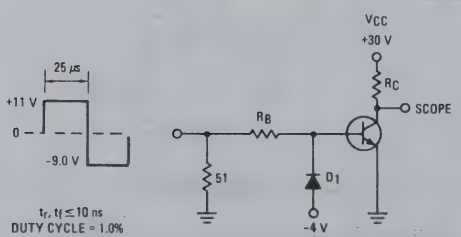
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	2N5986, 2N5989	$V_{CEO(sus)}$	40	–	Vdc
	2N5987, 2N5990		60	–	
	2N5988, 2N5991		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N5986, 2N5989		–	2.0	
(V_{CE} = 30 Vdc, I_B = 0)	2N5987, 2N5990		–	2.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5988, 2N5991		–	2.0	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5986, 2N5989		–	200	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5987, 2N5990		–	200	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5988, 2N5991		–	200	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5986, 2N5989		–	2.0	mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5987, 2N5990		–	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5988, 2N5991		–	2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			40	–	
(I_C = 6.0 Adc, V_{CE} = 2.0 Vdc)			20	120	
(I_C = 12 Adc, V_{CE} = 2.0 Vdc)			7.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 6.0 Adc, I_B = 0.6 Adc)			–	0.7	
(I_C = 12 Adc, I_B = 1.8 Adc)			–	1.7	
Base-Emitter Saturation Voltage (I_C = 12 Adc, I_B = 1.8 Adc)		$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage (I_C = 6.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)		f_T	2.0	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N5986 thru 2N5988		–	500	
	2N5989 thru 2N5991		–	300	
Small-Signal Current Gain (I_C = 2.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

*Indicates JEDEC Registered Data.

(1) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈100 mA
MSD6100 USED BELOW I_B ≈100 mA

For PNP test circuit reverse diode and voltage polarities.

FIGURE 3 – TURN-ON TIME

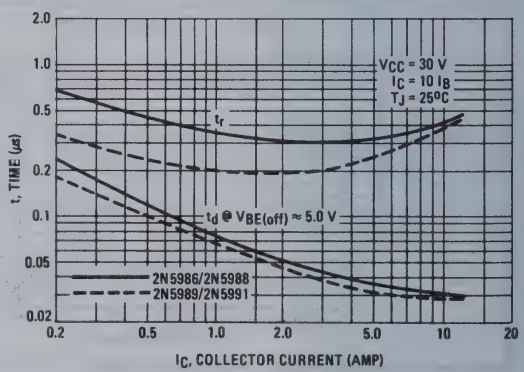


FIGURE 4 – THERMAL RESPONSE

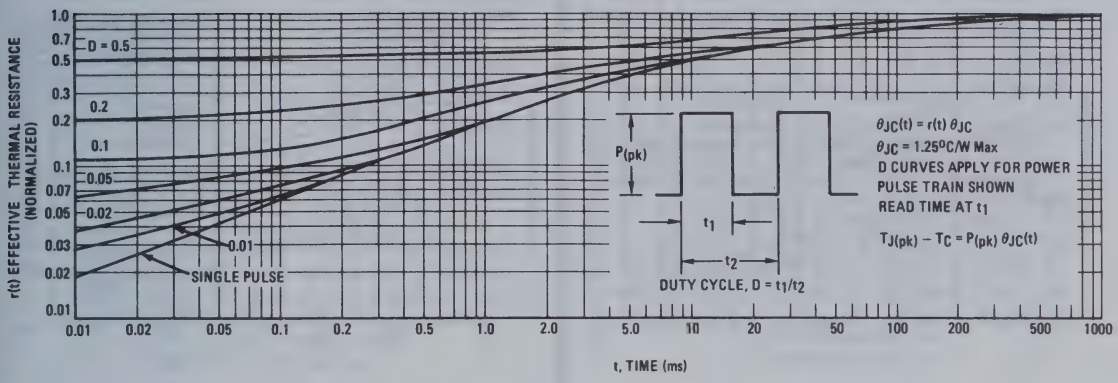
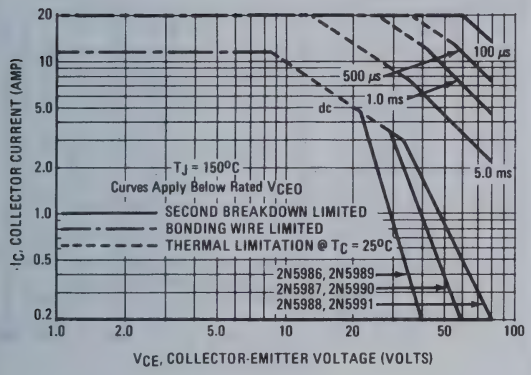


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^oC$ $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

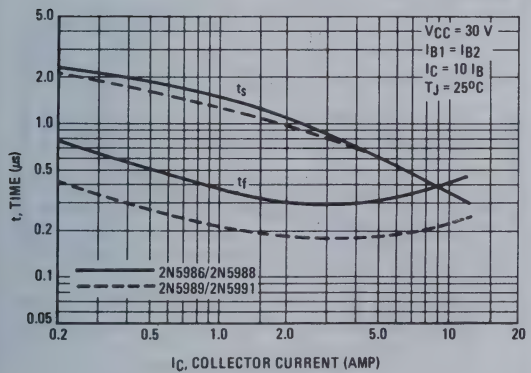
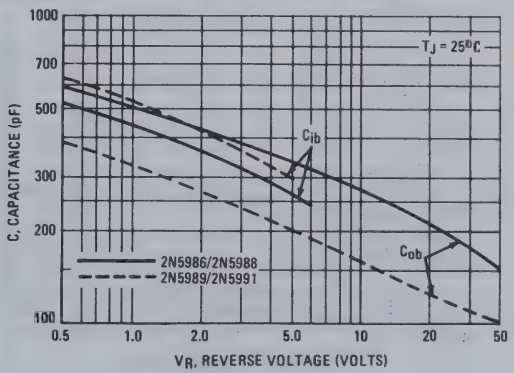


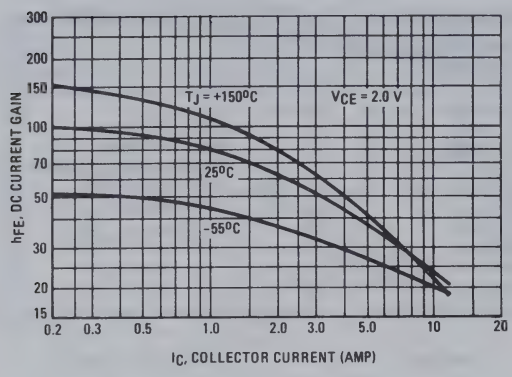
FIGURE 7 – CAPACITANCE



PNP
2N5986 thru 2N5988

NPN
2N5989 thru 2N5991

FIGURE 8 – DC CURRENT GAIN



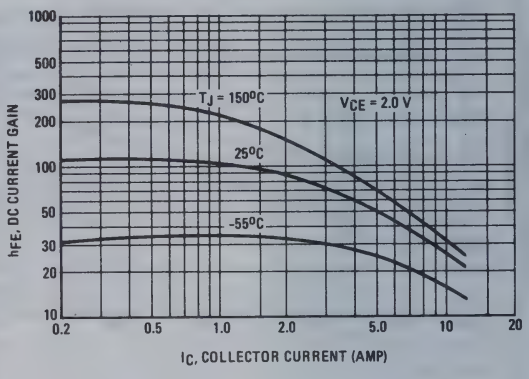
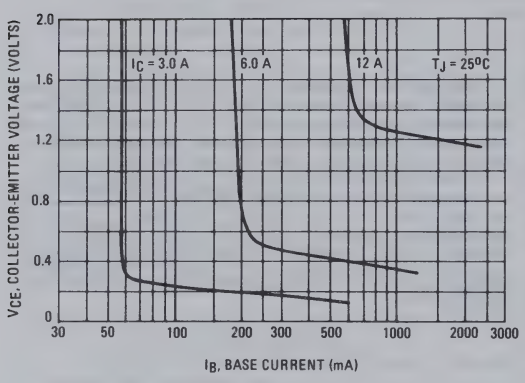


FIGURE 9 – COLLECTOR SATURATION REGION



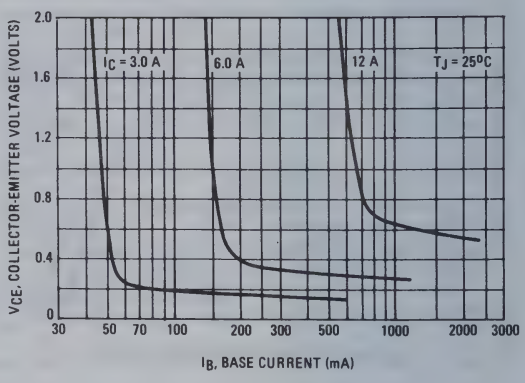
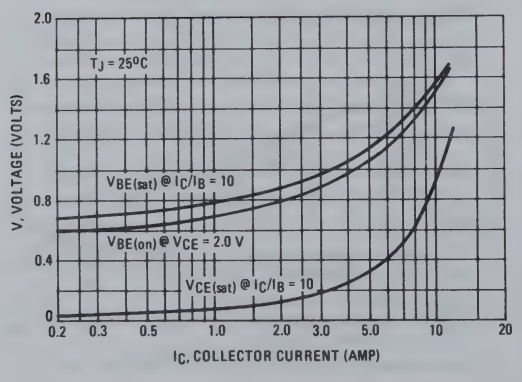
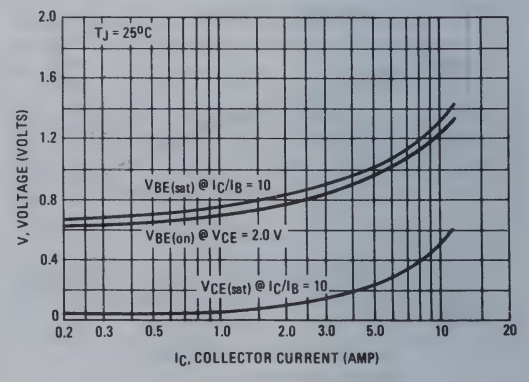


FIGURE 10 – "ON" VOLTAGES





PNP
2N5986 thru 2N5988

NPN
2N5989 thru 2N5991

FIGURE 11 – TEMPERATURE COEFFICIENTS

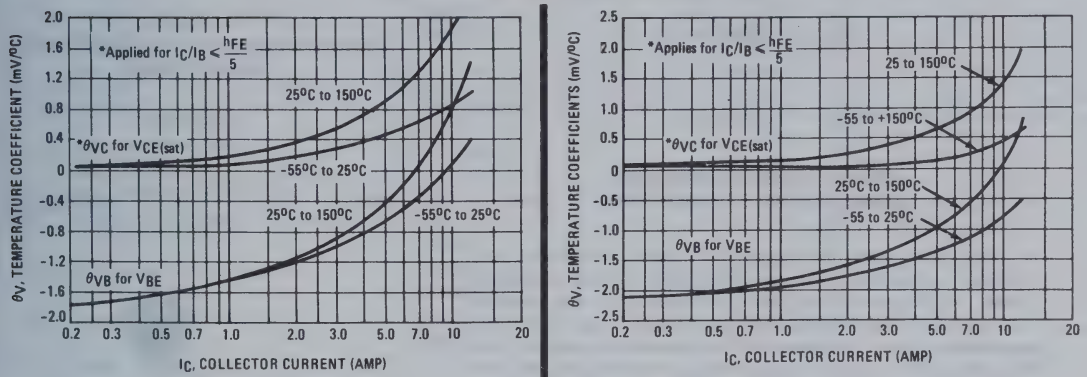


FIGURE 12 – COLLECTOR CUTOFF REGION

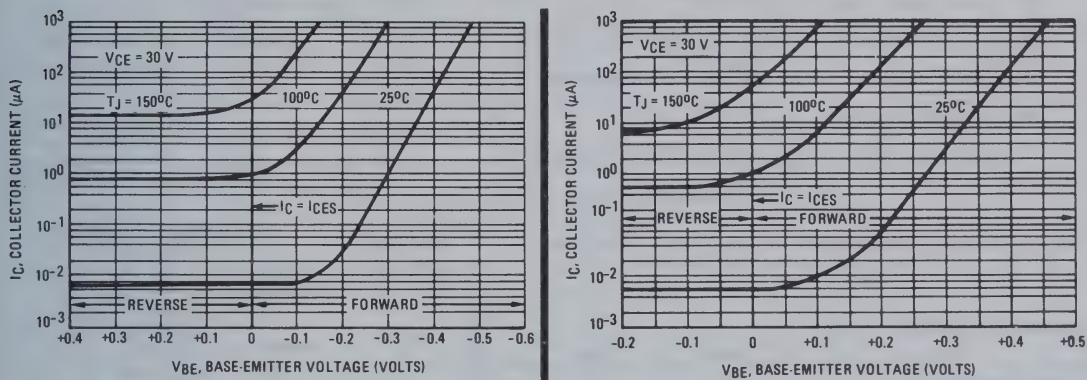
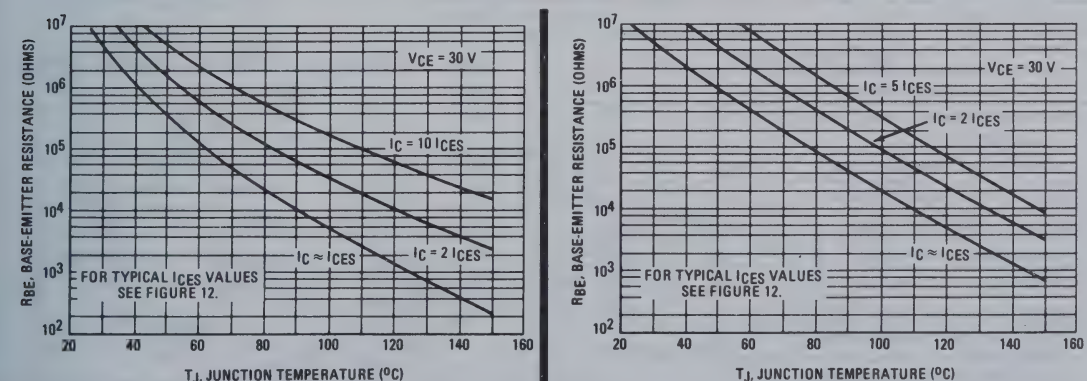
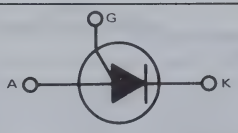


FIGURE 13 – EFFECTS OF EXTERNAL BASE-EMITTER RESISTANCE



2N6027 (SILICON)
2N6028



SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-trigger, oscillator, pulse and timing circuits. These devices may also be used in special thyristor applications due to the availability of an anode gate. Supplied in an inexpensive TO-92 plastic package for high-volume requirements, this package is readily adaptable for use in automatic insertion equipment.

- Programmable – R_{BB}, η, I_V and I_P.
- Low On-State Voltage – 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current – 10 nA Maximum
- High Peak Output Voltage – 11 Volts Typical
- Low Offset Voltage – 0.35 Volt Typical (R_G = 10 k ohms)

SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

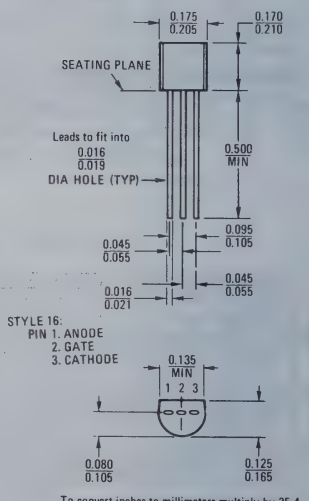
40 VOLTS
375 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation (1) Derate Above 25°C	P_F $1/\theta_{JA}$	375 5.0	mW mW/°C
DC Forward Anode Current (2) Derate Above 25°C	I_T	200 2.67	mA mA/°C
*DC Gate Current	I_G	±50	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle *20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
* Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
* Gate to Cathode Reverse Voltage	V_{GKR}	-5.0	Volt
* Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
* Anode to Cathode Voltage	V_{AK}	±40	Volt
Operating Junction Temperature Range	T_J	-50 to +100	°C
* Storage Temperature Range	T_{stg}	-55 to +150	°C

*Indicates JEDEC Registered Data
(1) JEDEC Registered Data is 300 mW, derating at 4.0 mW/°C.
(2) JEDEC Registered Data is 150 mA.



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

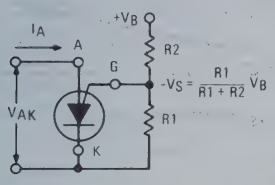
CASE 29-02
TO-92
PLASTIC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

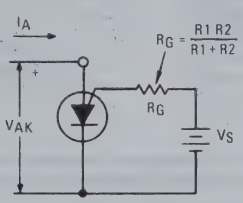
Characteristic		Figure	Symbol	Min	Typ	Max	Unit
*Peak Current		2,9,11	I_P				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	2N6027			–	1.25	2.0	
	2N6028			–	0.08	0.15	
(V_S = 10 Vdc, R_G = 10 k ohms)	2N6027			–	4.0	5.0	
	2N6028			–	0.70	1.0	
*Offset Voltage		1	V_T				Volts
(V_S = 10 Vdc, R_G = 1.0 MΩ)	2N6027			0.2	0.70	1.6	
	2N6028			0.2	0.50	0.6	
(V_S = 10 Vdc, R_G = 10 k ohms)	(Both Types)			0.2	0.35	0.6	
*Valley Current		1,4,5,	I_V				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	2N6027			–	18	50	
	2N6028			–	18	25	
(V_S = 10 Vdc, R_G = 10 k ohms)	2N6027			70	270	–	
	2N6028			25	270	–	
(V_S = 10 Vdc, R_G = 200 Ohms)	2N6027			1.5	–	–	mA
	2N6028			1.0	–	–	
* Gate to Anode Leakage Current		–	I_{GAO}				nAdc
(V_S = 40 Vdc, T_A = 25°C, Cathode Open)				–	1.0	10	
(V_S = 40 Vdc, T_A = 75°C, Cathode Open)				–	3.0	–	
Gate to Cathode Leakage Current (V_S = 40 Vdc, Anode to Cathode Shorted)		–	I_{GKS}	–	5.0	50	nAdc
*Forward Voltage (I_F = 50 mA Peak)		1,6	V_F	–	0.8	1.5	Volts
* Peak Output Voltage (V_B = 20 Vdc, C_C = 0.2 μF)		3,7	V_O	6.0	11	–	Volts
Pulse Voltage Rise Time (V_B = 20 Vdc, C_C = 0.2 μF)		3	t_r	–	40	80	ns

*Indicates JEDEC Registered Data

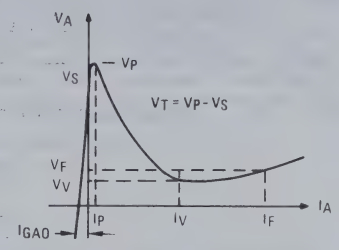
FIGURE 1 – ELECTRICAL CHARACTERIZATION



1A - PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2



1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)



1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (Ip) TEST CIRCUIT

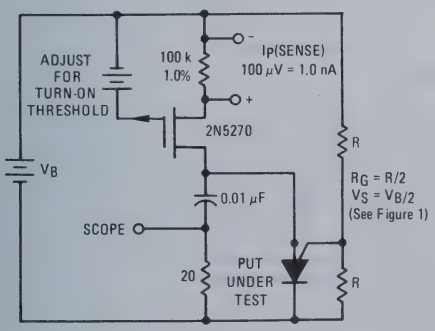
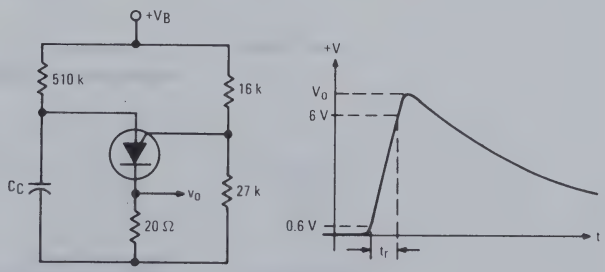


FIGURE 3 – V_O AND t_r TEST CIRCUIT



TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

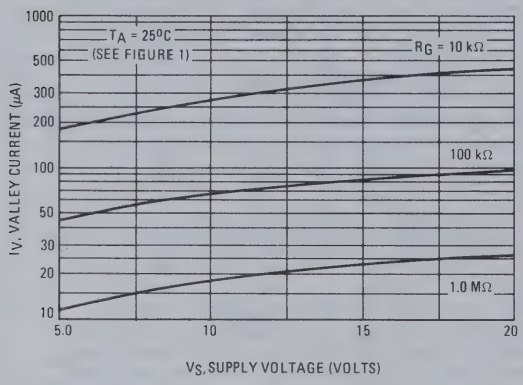


FIGURE 5 – EFFECT OF TEMPERATURE

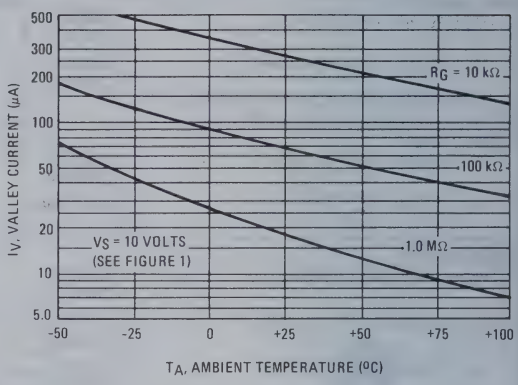


FIGURE 6 – FORWARD VOLTAGE

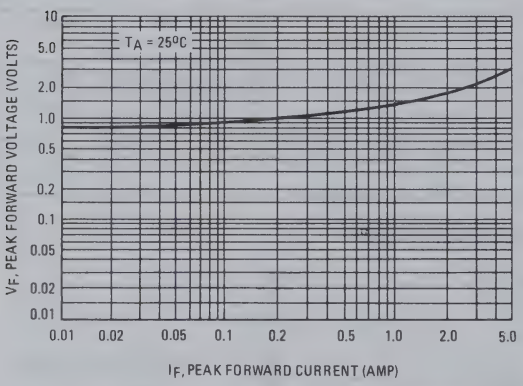


FIGURE 7 – PEAK OUTPUT VOLTAGE

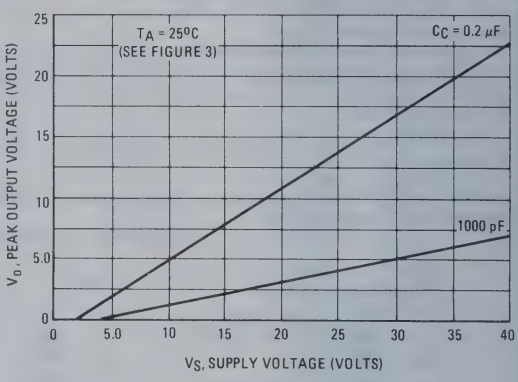
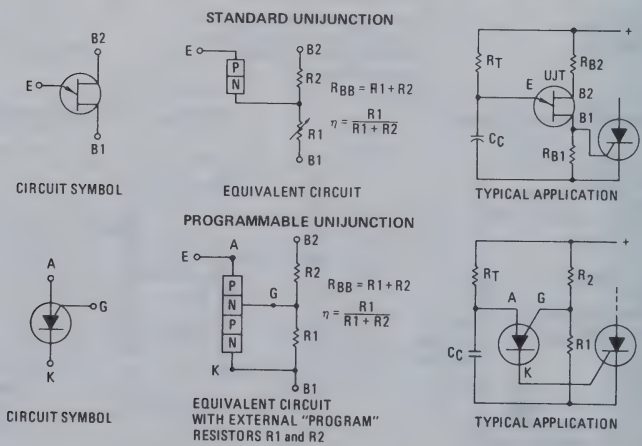


FIGURE 8 – STANDARD UNIJUNCTION COMPARED TO PROGRAMMABLE UNIJUNCTION



TYPICAL PEAK CURRENT BEHAVIOR

2N6027

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

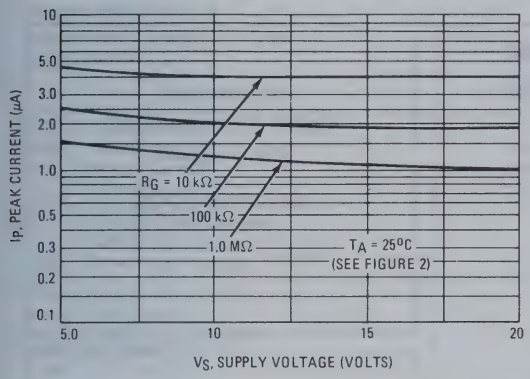
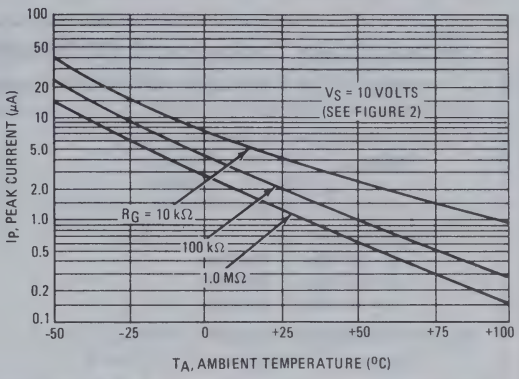


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



2N6028

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

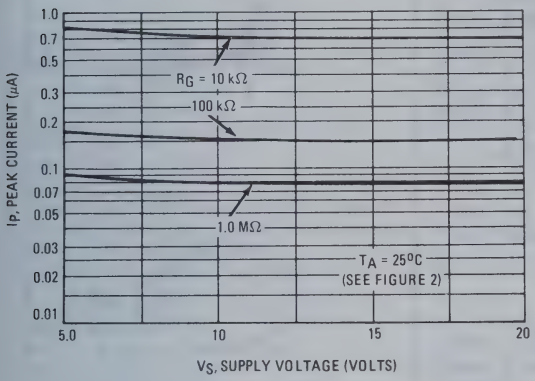
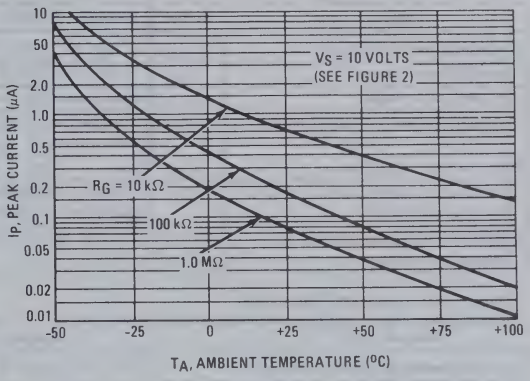


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



2N6029 (SILICON)
2N6030
2N6031

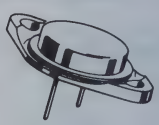
HIGH-VOLTAGE — HIGH POWER PNP TRANSISTORS

. . . designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 100 Vdc — 2N6029
  = 120 Vdc — 2N6030
  = 140 Vdc — 2N6031
- High DC Current Gain — @ I_C = 8.0 Adc
  h_{FE} = 25 (Min) — 2N6029
  = 20 (Min) — 2N6030
  = 15 (Min) — 2N6031
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 Adc
- Complement to NPN Transistor Series — 2N5629, 2N5630, 2N5631

16 AMPERE
POWER TRANSISTORS
PNP SILICON

100-120-140 VOLTS
200 WATTS



*MAXIMUM RATINGS

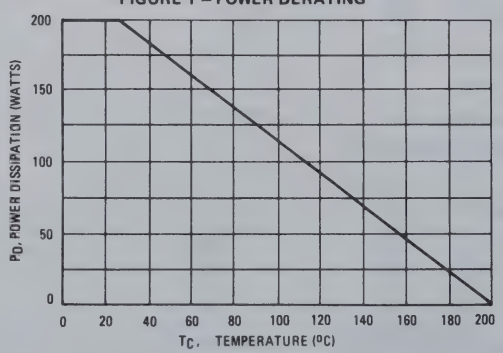
Rating	Symbol	2N6029	2N6030	2N6031	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous	I_C	← 16 →			Adc
Peak		← 20 →			
Base Current — Continuous	I_B	← 5.0 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 200 →			Watts
Derate above 25°C		← 1.14 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

*THERMAL CHARACTERISTICS

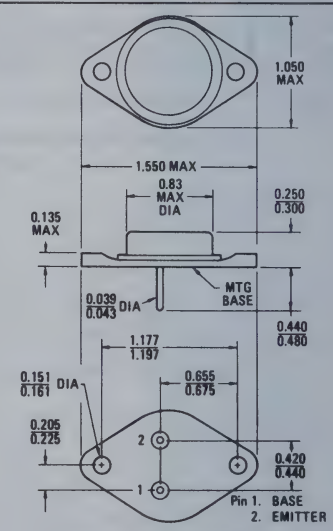
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER DERATING



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



All JEDEC dimensions and notes apply

Collector connected to case

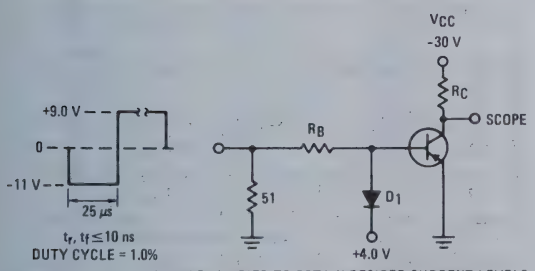
CASE 11
TO-3

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	2N6029	$V_{CEO(sus)}$	100	–	Vdc
	2N6030		120	–	
	2N6031		140	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6029		–	2.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N6030		–	2.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N6031		–	2.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	2.0	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	7.0	
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	2.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)	2N6029		25	100	
	2N6030		20	80	
	2N6031		15	60	
(I_C = 16 Adc, V_{CE} = 2.0 Vdc)	All Types		4.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			–	1.0	
(I_C = 16 Adc, I_B = 4.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	–	1.8	Vdc
Base-Emitter On Voltage (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 20 Vdc, f_{test} = 0.5 MHz)		f_T	1.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	1000	pF
Small-Signal Current Gain (I_C = 4.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	15	–	–

*Indicates JEDEC Registered Data. (1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%. (2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

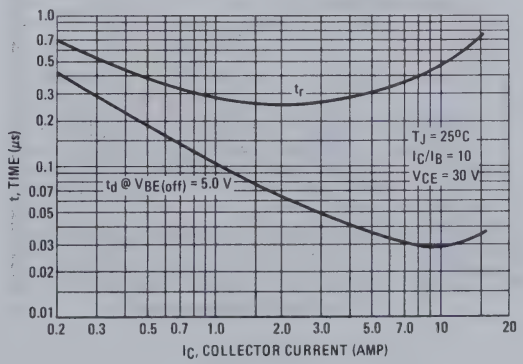


FIGURE 4 – THERMAL RESPONSE

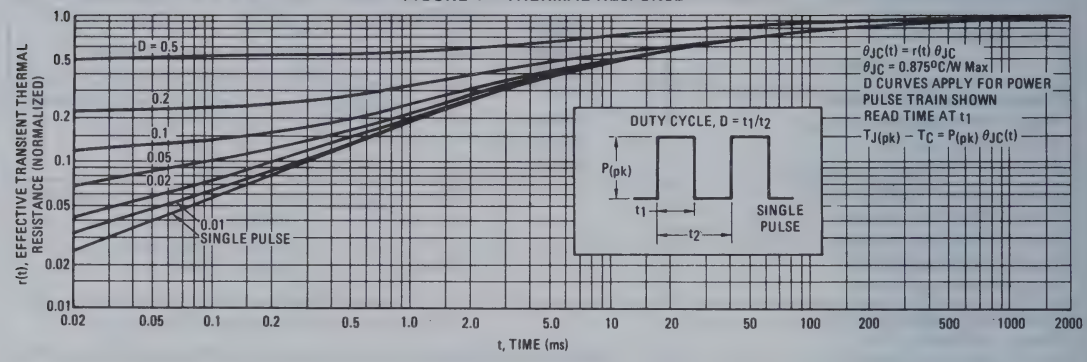
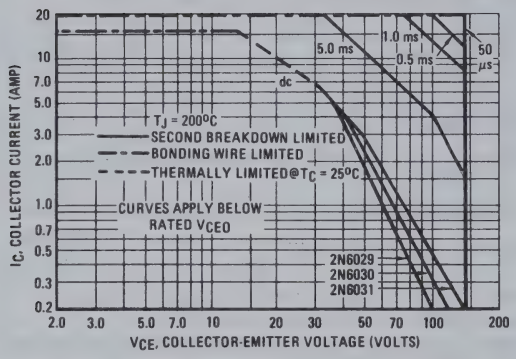


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

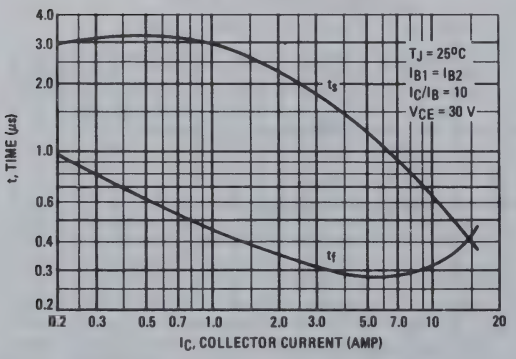


FIGURE 7 – CAPACITANCE

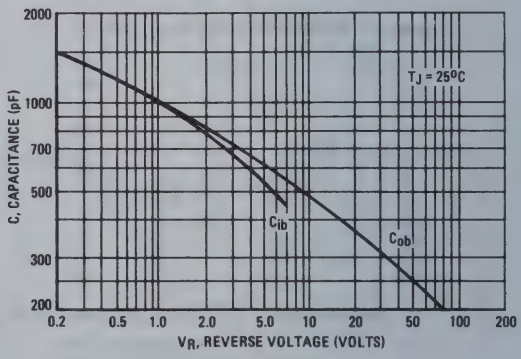


FIGURE 8 – DC CURRENT GAIN

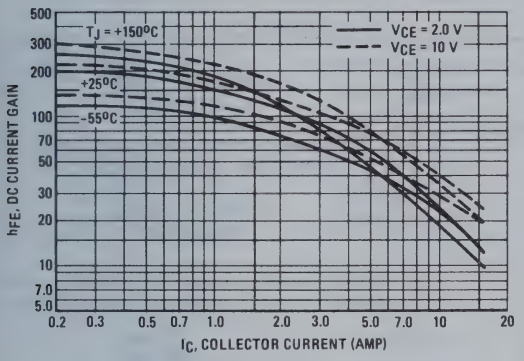


FIGURE 9 – COLLECTOR SATURATION REGION

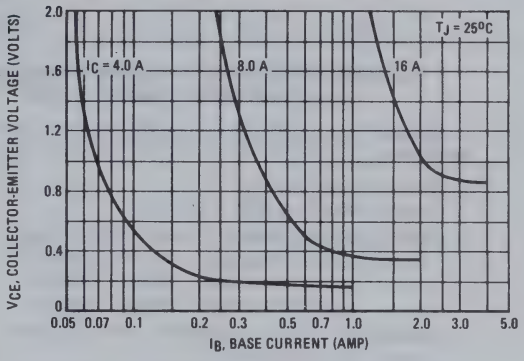


FIGURE 10 – "ON" VOLTAGES

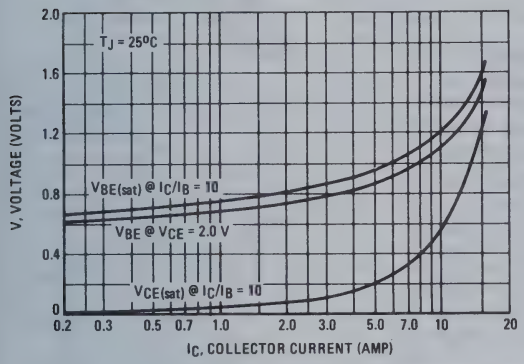


FIGURE 11 – TEMPERATURE COEFFICIENTS

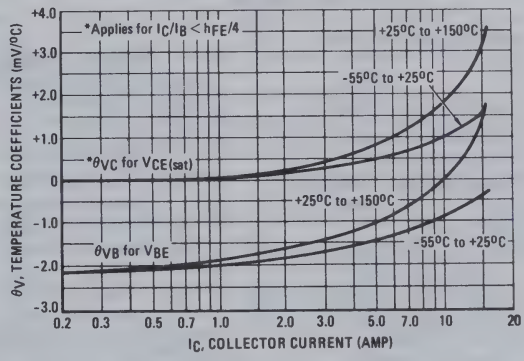


FIGURE 12 – COLLECTOR CUTOFF REGION

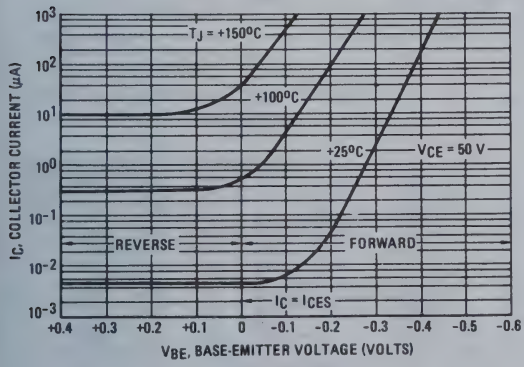
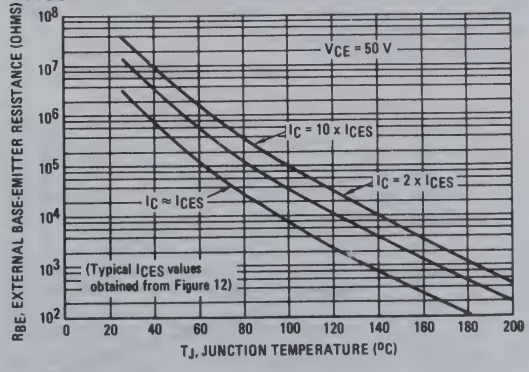


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N6034, 2N6035, 2N6036 PNP (SILICON)
2N6037, 2N6038, 2N6039 NPN

PLASTIC DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain –
  h_{FE} = 2000 (Typ) @ I_C = 2.0 Adc
- Collector-Emitter Sustaining Voltage – @ 100 mAdc
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N6034, 2N6037
  = 60 Vdc (Min) – 2N6035, 2N6038
  = 80 Vdc (Min) – 2N6036, 2N6039
- Forward Biased Second Breakdown Current Capability
  $I_{S/b}$ = 1.5 Adc @ 25 Vdc
- Monolithic Construction with Built-In Base-Emitter Resistors to Limit Leakage Multiplication
- Space-Saving High Performance-to-Cost Ratio
  Case 77 Plastic Package

DARLINGTON 4-AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

40, 60, 80 VOLTS
40 WATTS



*MAXIMUM RATINGS

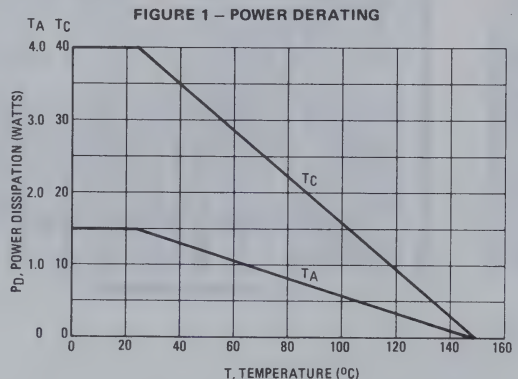
Rating	Symbol	2N6034 2N6037	2N6035 2N6038	2N6036 2N6039	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	4.0			Adc
Peak		8.0			
Base Current	I_B	100			mAdc
Total Device Dissipation @ T_C = 25°C	P_D	40			Watts
Derate above 25°C		0.32			W/°C
Total Device Dissipation @ T_A = 25°C	P_D	1.5			Watts
Derate above 25°C		0.012			W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150			°C

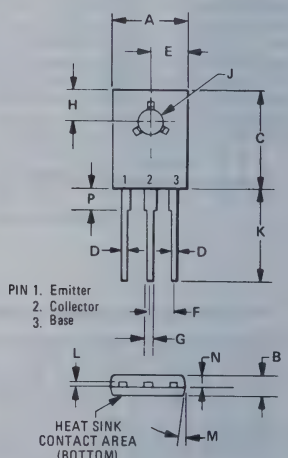
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.3	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.490	7.750	0.295	0.305
B	2.410	2.670	0.095	0.105
C	10.800	11.050	0.425	0.435
D	0.508	0.660	0.020	0.026
E	3.680	3.940	0.145	0.155
F	2.360 TP		0.093 TP	
G	0.635	0.889	0.025	0.035
H	3.760	4.010	0.148	0.158
J	2.920	3.000	0.115	0.118
K	15.110	16.380	0.595	0.645
L	0.381	0.635	0.015	0.025
M	3° TYP		3° TYP	
N	1.140	1.400	0.045	0.055
P	2.160	2.410	0.085	0.095

Collector connected to case

CASE 77-03

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N6034, 2N6037		40	–	
	2N6035, 2N6038		60	–	
	2N6036, 2N6039		80	–	
Collector-Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N6034, 2N6037		–	0.5	
(V_{CE} = 30 Vdc, I_B = 0)	2N6035, 2N6038		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N6036, 2N6039		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6034, 2N6037		–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6035, 2N6038		–	0.5	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6036, 2N6039		–	0.5	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6034, 2N6037		–	2.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6035, 2N6038		–	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6036, 2N6039		–	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N6034, 2N6037		–	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N6035, 2N6038		–	0.5	
(V_{CB} = 80 Vdc, I_E = 0)	2N6036, 2N6039		–	0.5	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 3.0 Vdc)			500	–	
(I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)			750	15,000	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 8.0 mAdc)			–	2.0	
(I_C = 4.0 Adc, I_B = 40 mAdc)			–	3.0	
Base-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 40 mAdc)		$V_{BE(sat)}$	–	4.0	Vdc
Base-Emitter On Voltage (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Small-Signal Current-Gain (I_C = 0.75 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	25	–	–
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E =0, f = 0.1 MHz)	2N6034, 2N6035, 2N6036		–	200	
	2N6037, 2N6038, 2N6039		–	100	

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT

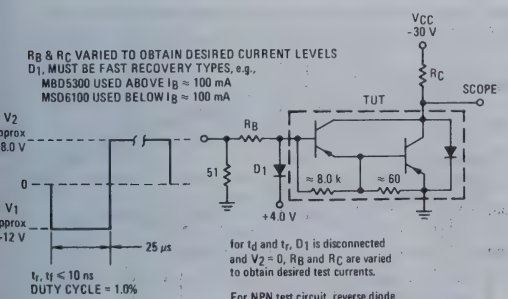


FIGURE 3 – SWITCHING TIMES

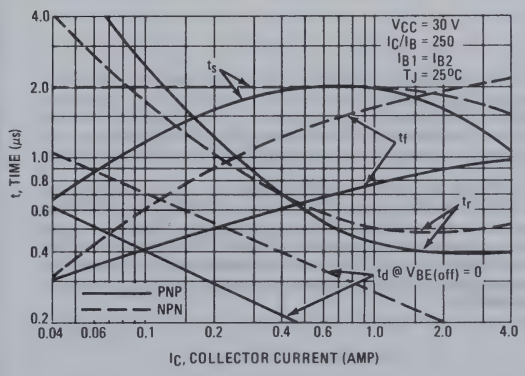
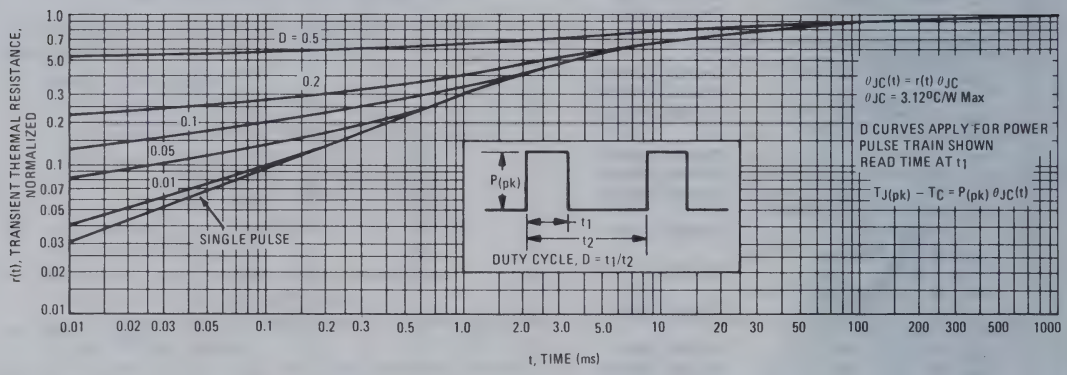


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE-OPERATING AREA

FIGURE 5 – 2N6034, 2N6035, 2N6036

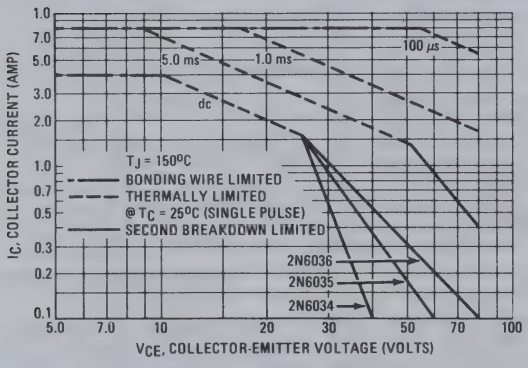
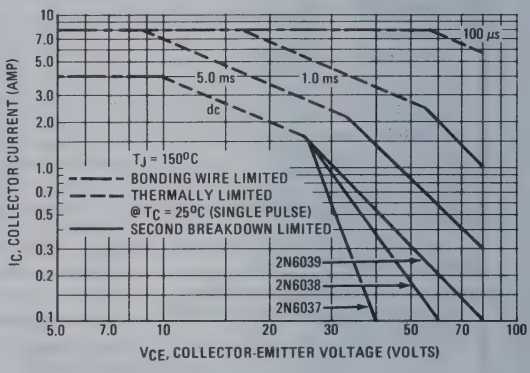


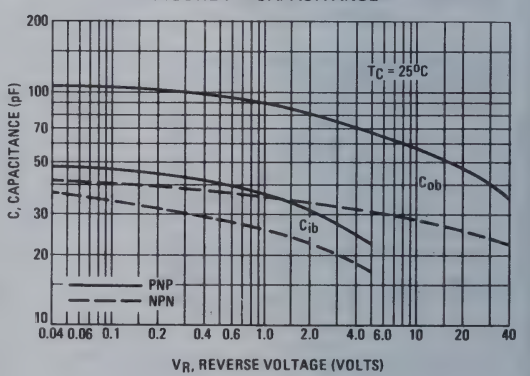
FIGURE 6 – 2N6037, 2N6038, 2N6039



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

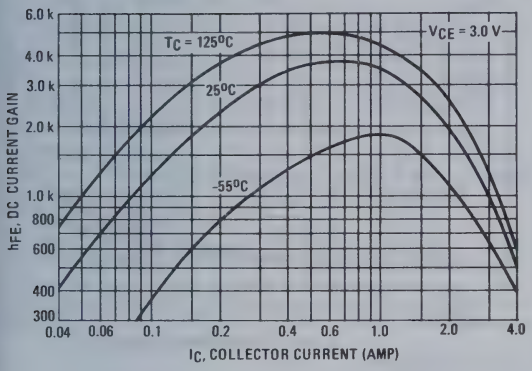
FIGURE 7 – CAPACITANCE



PNP
2N6034, 2N6035, 2N6036

NPN
2N6037, 2N6038, 2N6039

FIGURE 8 – DC CURRENT GAIN



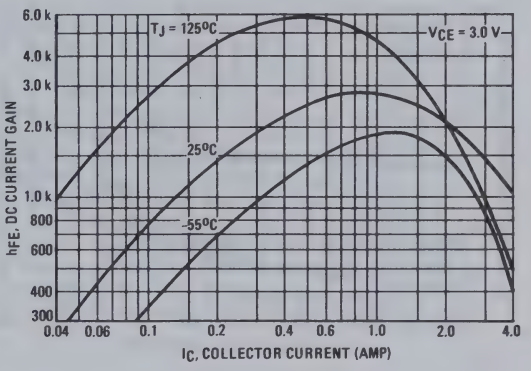
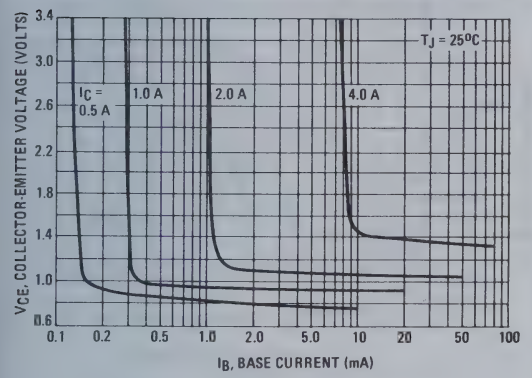


FIGURE 9 – COLLECTOR SATURATION REGION



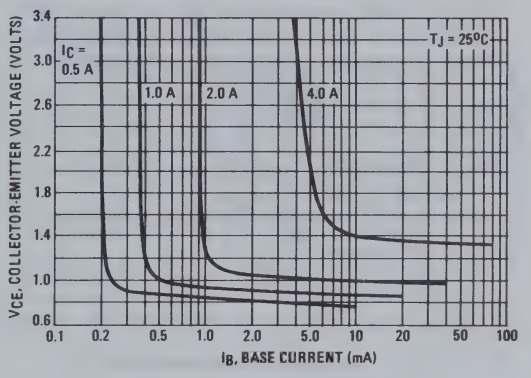
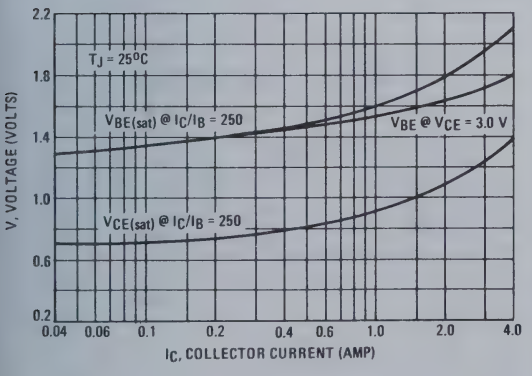
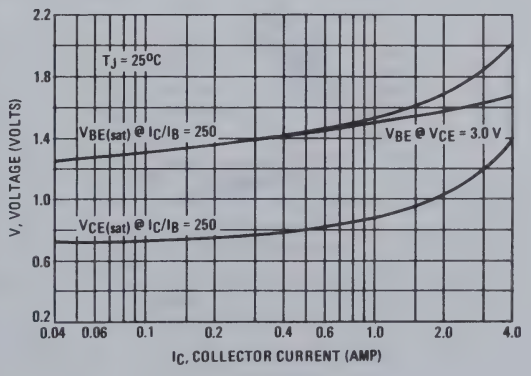


FIGURE 10 – "ON" VOLTAGES

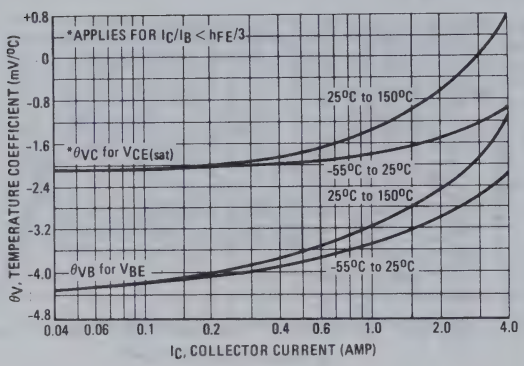




PNP
2N6034, 2N6035, 2N6036

NPN
2N6037, 2N6038, 2N6039

FIGURE 11 – TEMPERATURE COEFFICIENCTS



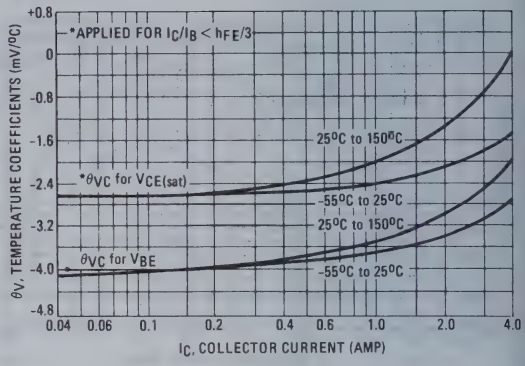
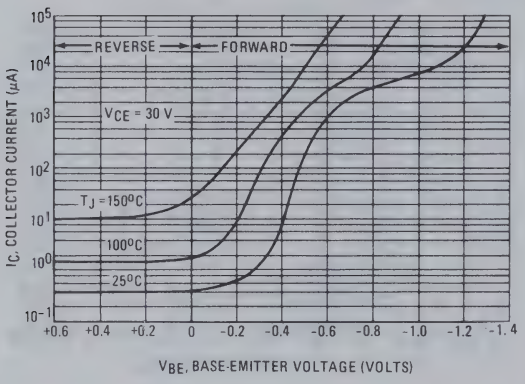


FIGURE 12 – COLLECTOR CUT-OFF REGION



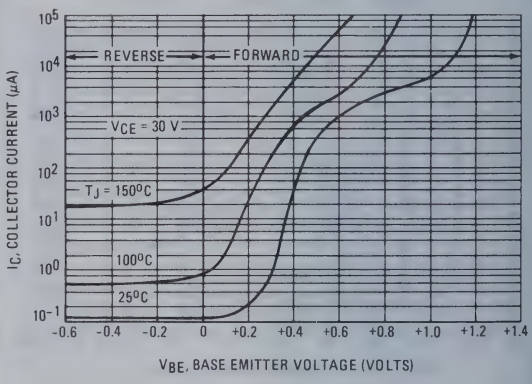
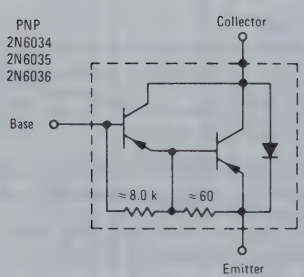
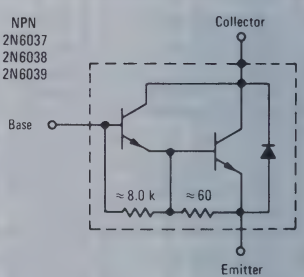


FIGURE 13 – DARLINGTON SCHEMATIC





2N6040 thru 2N6042 PNP (SILICON)
2N6043 thru 2N6045 NPN
MJE6040 thru MJE6042 PNP
MJE6043 thru MJE6045 NPN

PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain –
  h_{FE} = 2500 (Typ) @ I_C = 4.0 Adc
- Collector-Emitter Sustaining Voltage – @ 100 mAdc (1)
  $V_{CEO(sus)}$ = 60 Vdc (Min) – 2N6040, 2N6043
  = 80 Vdc (Min) – 2N6041, 2N6044
  = 100 Vdc (Min) – 2N6042, 2N6045
- Low Collector-Emitter Saturation Voltage – (1)
  $V_{CE(sat)}$ = 2.0 Vdc (Max) @ I_C = 4.0 Adc – 2N6040,41,2N6043,44
  = 2.0 Vdc (Max) @ I_C = 3.0 Adc – 2N6042, 2N6045
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors
- Thermopad High Efficiency Compact Package

(1) Applies to corresponding in-house part numbers also.

DARLINGTON 8 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60-80-100 VOLTS
75 WATTS

***MAXIMUM RATINGS**

Rating	Symbol	2N6040 2N6043 MJE6040 MJE6043	2N6041 2N6044 MJE6041 MJE6044	2N6042 2N6045 MJE6042 MJE6045	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current – Continuous Peak	I_C	← 8.0 → ← 16 →			Adc
Base Current	I_B	← 120 →			mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 75 → ← 0.60 →			Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 2.2 → ← 0.0175 →			Watts W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.67	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	57	°C/W

*Indicates JEDEC Registered Data.

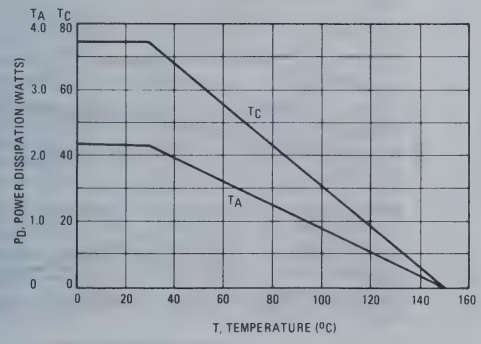
2N6040 thru 2N6045



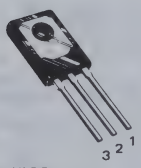
PIN 1. BASE
2. COLLECTOR
3. EMITTER

CASE 199-04

FIGURE 1 – POWER DERATING



MJE6040 thru MJE6045



PIN 1. EMITTER
2. COLLECTOR
3. BASE

CASE 90-05

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	2N6040, 2N6043, MJE6040, MJE6043	$V_{CEO(sus)}$	60	–	Vdc
	2N6041, 2N6044, MJE6041, MJE6044		80	–	
	2N6042, 2N6045, MJE6042, MJE6045		100	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N6040, 2N6043, MJE6040, MJE6043		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N6041, 2N6044, MJE6041, MJE6044		–	0.5	
(V_{CE} = 50 Vdc, I_B = 0)	2N6042, 2N6045, MJE6042, MJE6045		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6040, 2N6043, MJE6040, MJE6043		–	0.5	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6041, 2N6044, MJE6041, MJE6044		–	0.5	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6042, 2N6045, MJE6042, MJE6045		–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6040, 2N6043, MJE6040, MJE6043		–	5.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6041, 2N6044, MJE6041, MJE6044		–	5.0	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N6042, 2N6045, MJE6042, MJE6045		–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N6040, 2N6043, MJE6040, MJE6043		–	0.5	
(V_{CB} = 80 Vdc, I_E = 0)	2N6041, 2N6044, MJE6041, MJE6044		–	0.5	
(V_{CB} = 100 Vdc, I_E = 0)	2N6042, 2N6045, MJE6042, MJE6045		–	0.5	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	2N6040,41, 2N6043,44, MJE6040,41, MJE6043,44		1000	20,000	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	2N6042, 2N6045, MJE6042, MJE6045		1000	20,000	
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	All Types		100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 16 mAdc)	2N6040,41,2N6043,44,MJE6040,41,MJE6043,44		–	2.0	
(I_C = 3.0 Adc, I_B = 12 mAdc)	2N6042,2N6045,MJE6042,MJE6045		–	2.0	
(I_C = 8.0 Adc, I_B = 80 mAdc)	All Types		–	4.0	
Base-Emitter Saturation Voltage (I_C = 8.0 Adc, I_B = 80 mAdc)		$V_{BE(sat)}$	–	4.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	4.0	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N6040/2N6042, MJE6040/MJE6042		–	300	
	2N6043/2N6045, MJE6043/MJE6045		–	200	
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT

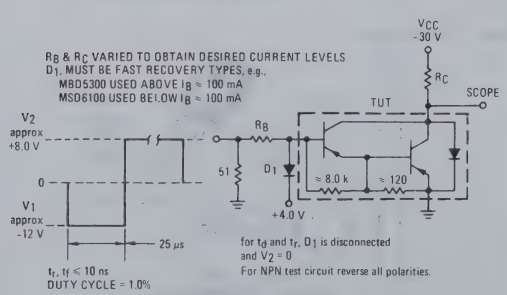


FIGURE 3 – SWITCHING TIMES

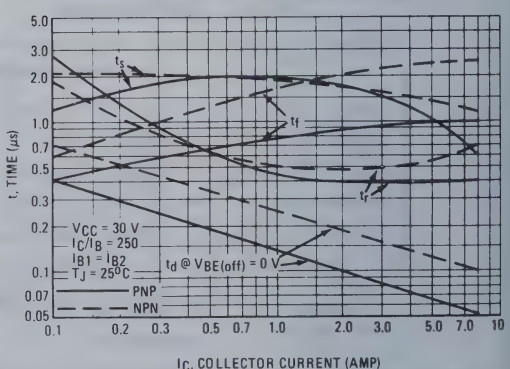


FIGURE 4 – THERMAL RESPONSE

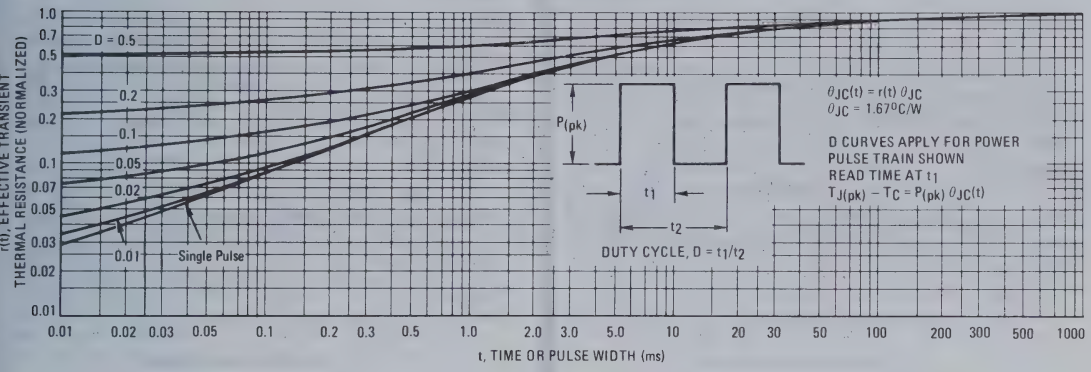
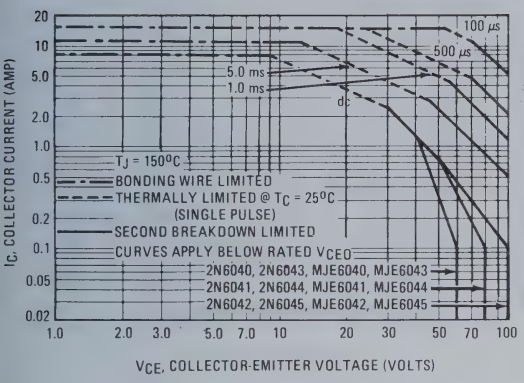


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

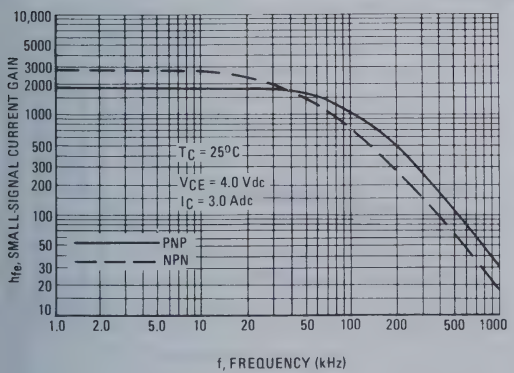
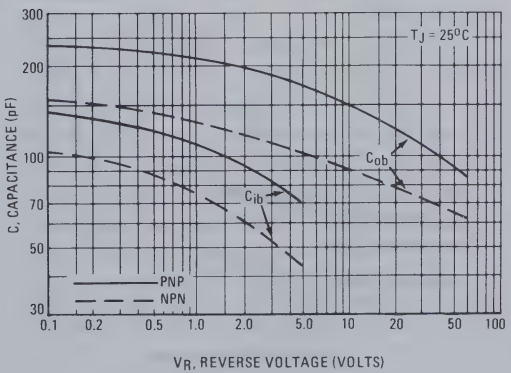


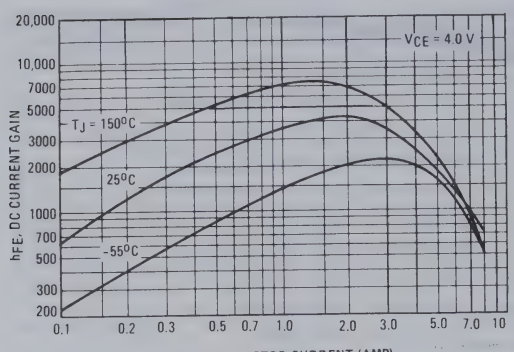
FIGURE 7 – CAPACITANCE



PNP
2N6040, 2N6041, 2N6042
MJE6040, MJE6041, MJE6042

NPN
2N6043, 2N6044, 2N6045
MJE6043, MJE6044, MJE6045

FIGURE 8 – DC CURRENT GAIN



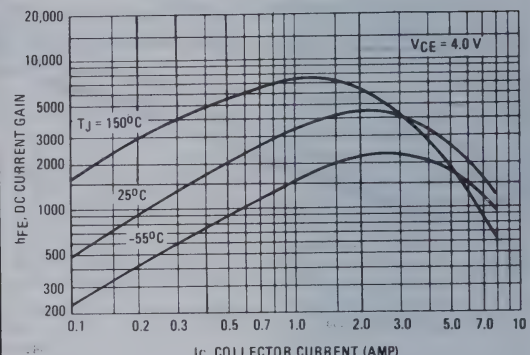
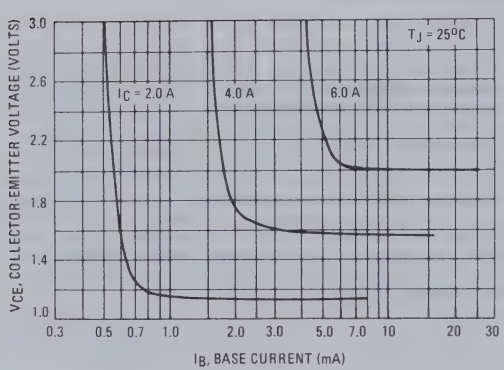


FIGURE 9 – COLLECTOR SATURATION REGION



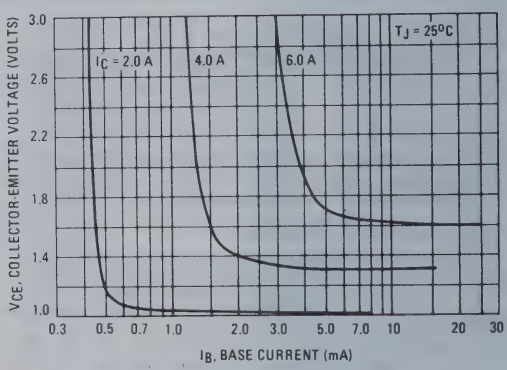
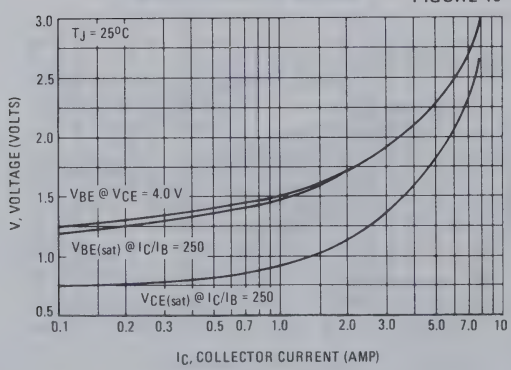
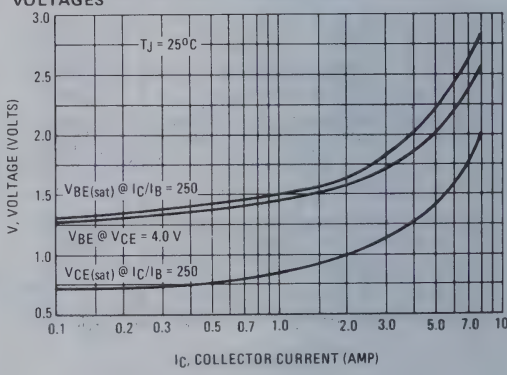


FIGURE 10 – "ON" VOLTAGES





PNP
2N6040, 2N6041, 2N6042
MJE6040, MJE6041, MJE6042

NPN
2N6043, 2N6044, 2N6045
MJE6043, MJE6044, MJE6045

FIGURE 11 – TEMPERATURE COEFFICIENTS

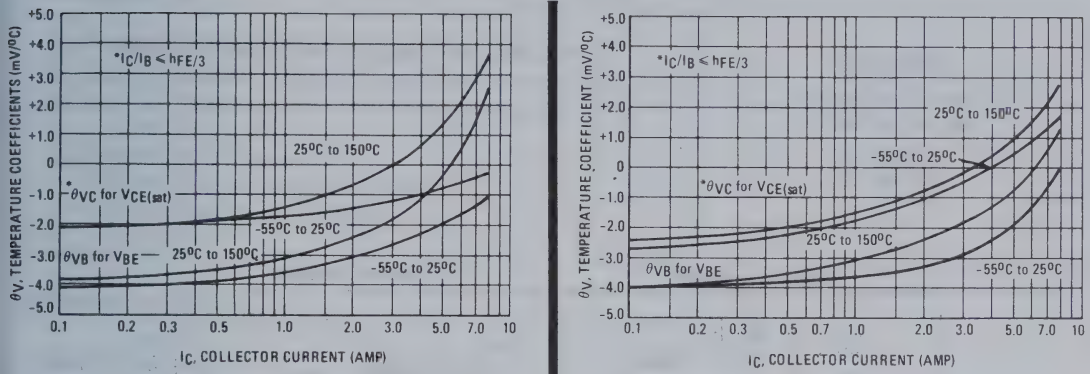


FIGURE 12 – COLLECTOR CUT-OFF REGION

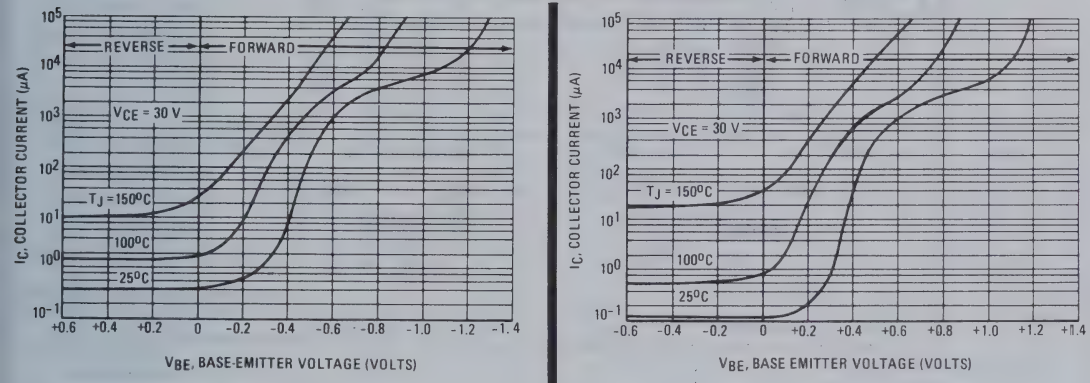
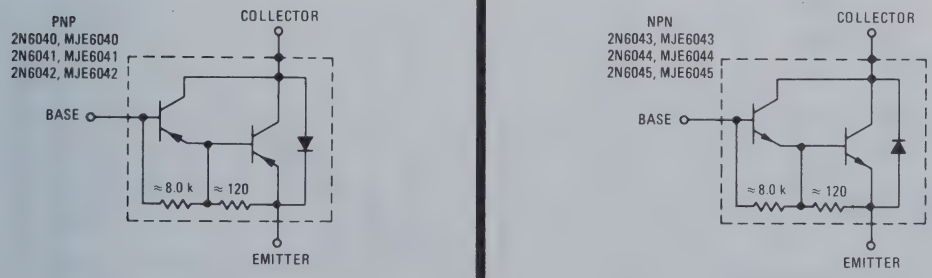
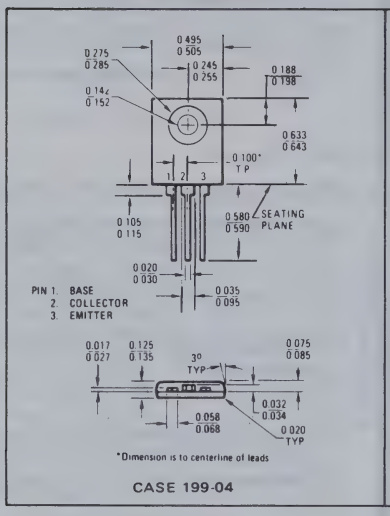


FIGURE 13 – DARLINGTON SCHEMATIC

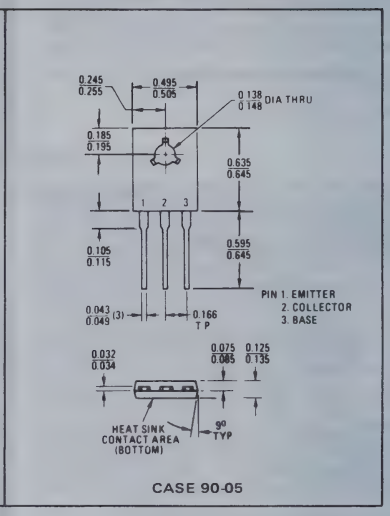


2N6040 thru 2N6045



CASE 199-04

MJE6040 thru MJE6045



CASE 90-05

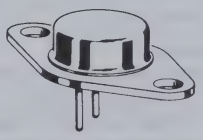
2N6049 (SILICON)

MEDIUM-POWER PNP SILICON TRANSISTOR

. . . designed for general-purpose switching and amplifier applications

- Aluminum TO-66 Package for Better Power Handling Capability – 75 Watts @ $T_C = 25^oC$
- Excellent Safe Operating Area
- DC Current Gain Specified to 4.0 Amperes
- Complement to NPN Type 2N3054A

4 AMPERE
POWER TRANSISTOR
PNP SILICON
55 VOLTS
75 WATTS



***MAXIMUM RATINGS**

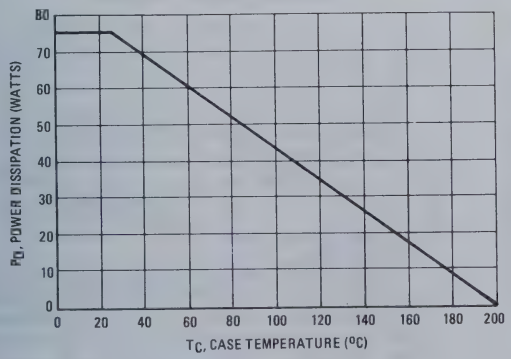
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous Peak	I_C	4.0 10	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25°	P_D	75 0.43	Watts W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	−65 to +200	°C

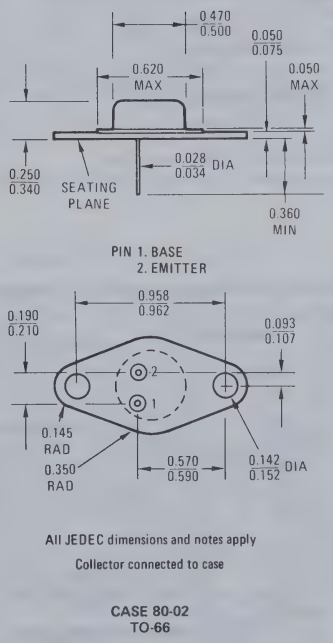
*Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.33	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 80-02
TO-66

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	55	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, R_{BE} = 100 Ω	$V_{CER(sus)}$	60	–	Vdc
Collector Cuttoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	500	μAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	1.0 6.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 4.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	25 6.0	100	– –
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 4.0 Adc, I_B = 800 mAdc)	$V_{CE(sat)}$	– –	0.5 2.0	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc)	f_T	3.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	200	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	25	180	

*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUIT

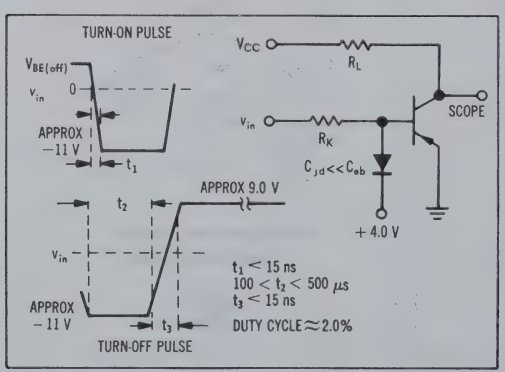


FIGURE 3 – TURN-ON TIME

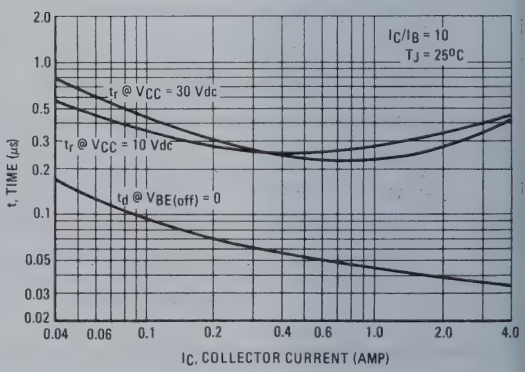


FIGURE 4 – THERMAL RESPONSE

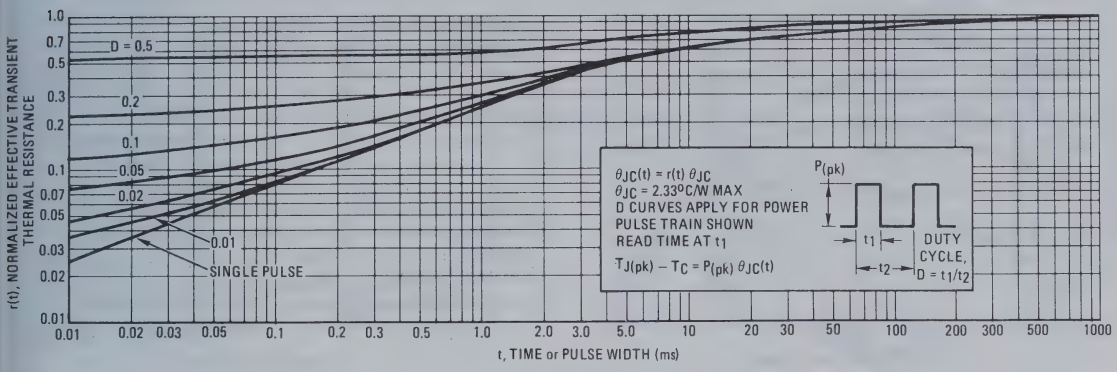
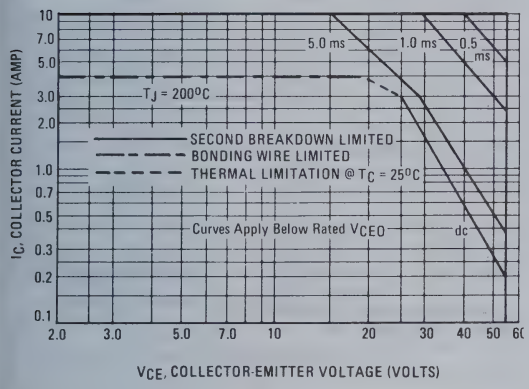


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

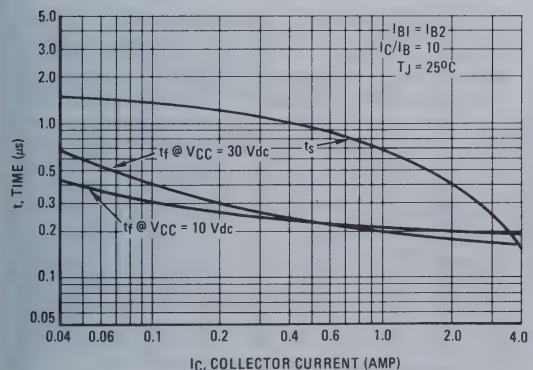


FIGURE 7 – CAPACITANCE

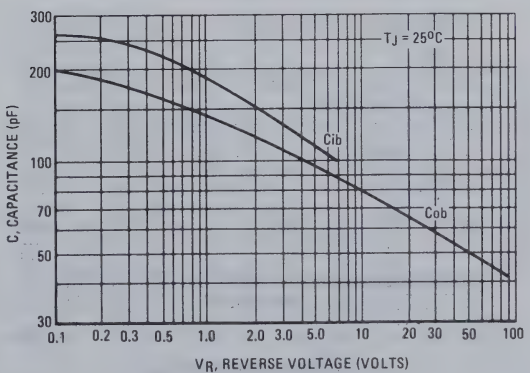


FIGURE 8 – DC CURRENT GAIN

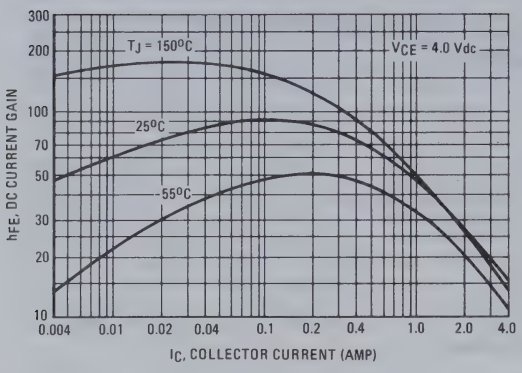


FIGURE 9 – COLLECTOR SATURATION REGION

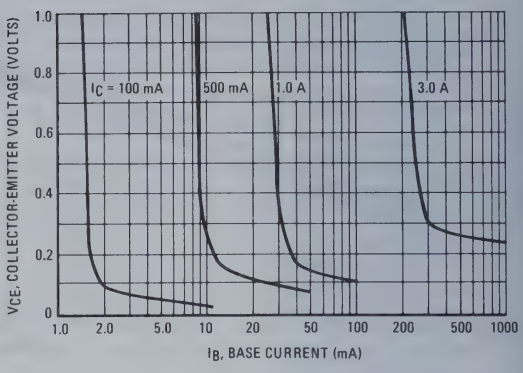


FIGURE 10 – TEMPERATURE COEFFICIENT

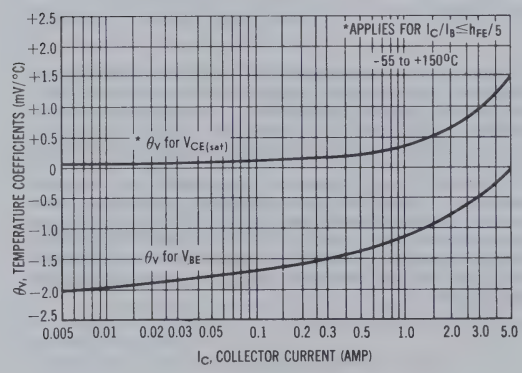


FIGURE 11 – "ON" VOLTAGES

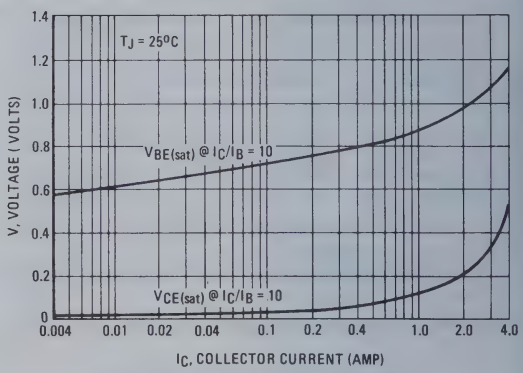


FIGURE 12 – COLLECTOR CUT-OFF REGION

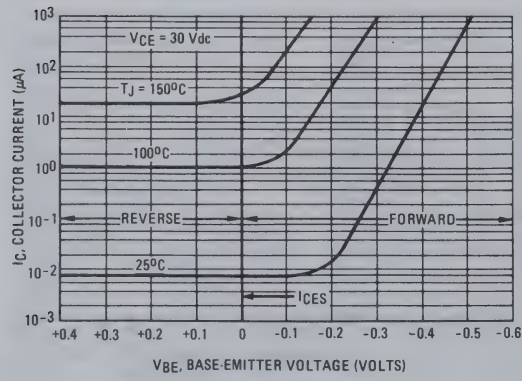
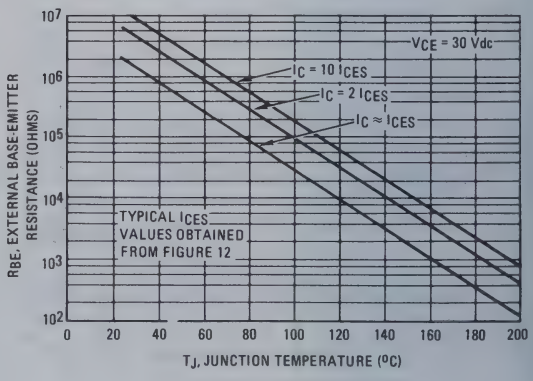


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



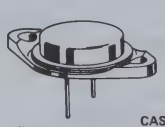
2N6050 thru 2N6052 PNP (SILICON)
2N6057 thru 2N6059 NPN

DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain — h_{FE} = 3500 (Typ) @ I_C = 5.0 Adc
- Collector-Emitter Sustaining Voltage — @ 100 mA
  $V_{CEO(sus)}$ = 60 Vdc (Min) — 2N6050, 2N6057
  80 Vdc (Min) — 2N6051, 2N6058
  100 Vdc (Min) — 2N6052, 2N6059
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

DARLINGTON
12 AMPERE
COMPLEMENTARY SILICON POWER TRANSISTORS
60-80-100 VOLTS
150 WATTS



CASE 11
TO-3

***MAXIMUM RATINGS**

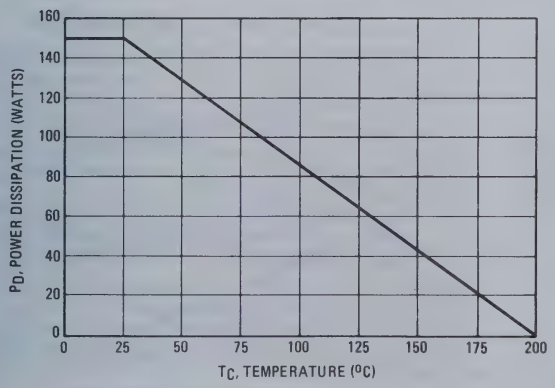
Rating	Symbol	2N6050 2N6057	2N6051 2N6058	2N6052 2N6059	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous Peak	I_C	12 20			Adc
Base Current	I_B	0.2			Adc
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	150 0.857			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200°C			°C

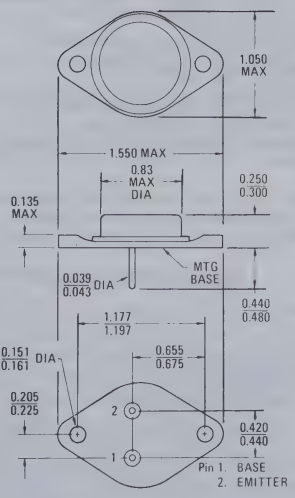
THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

•Indicates JEDEC Registered Data

FIGURE 1 — POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

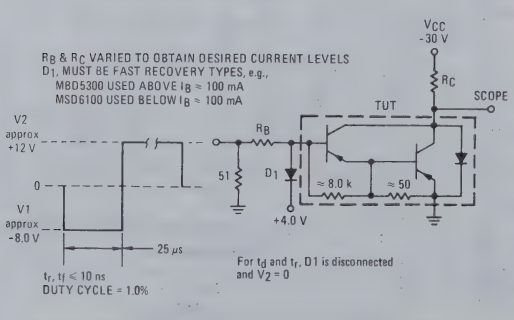
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N6050, 2N6057		60	–	
	2N6051, 2N6058		80	–	
	2N6052, 2N6059		100	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N6050, 2N6057		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N6051, 2N6058		–	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N6052, 2N6059		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)			–	0.5	
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)				5.0	
Emitter Cutoff Current		I_{EBO}	–	2.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 6.0 Adc, V_{CE} = 3.0 Vdc)			750	18,000	
(I_C = 12 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Volatage		$V_{CE(sat)}$			Vdc
(I_C = 6.0 Adc, I_B = 24 mAdc)			–	2.0	
(I_C = 12 Adc, I_B = 120 mAdc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	–	4.0	Vdc
(I_C = 12 Adc, I_B = 120 mAdc)					
Base-Emitter On Voltage		$V_{BE(on)}$	–	2.8	Vdc
(I_C = 6.0 Adc, V_{CE} = 3.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short Circuit Forward Current Transfer Ratio		$\lvert h_{fe} \rvert$	4.0	–	MHz
(I_C = 5.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)					
Output Capacitance	2N6050/2N6052	C_{ob}	–	500	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N6057/2N6059		–	300	
Small-Signal Current Gain		h_{fe}	300	–	–
(I_C = 5.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit reverse diode and voltage polarities.

FIGURE 3 – SWITCHING TIMES

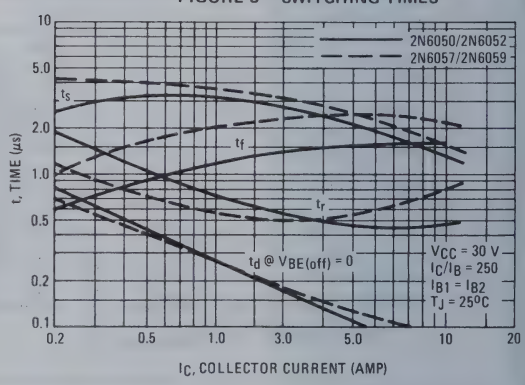
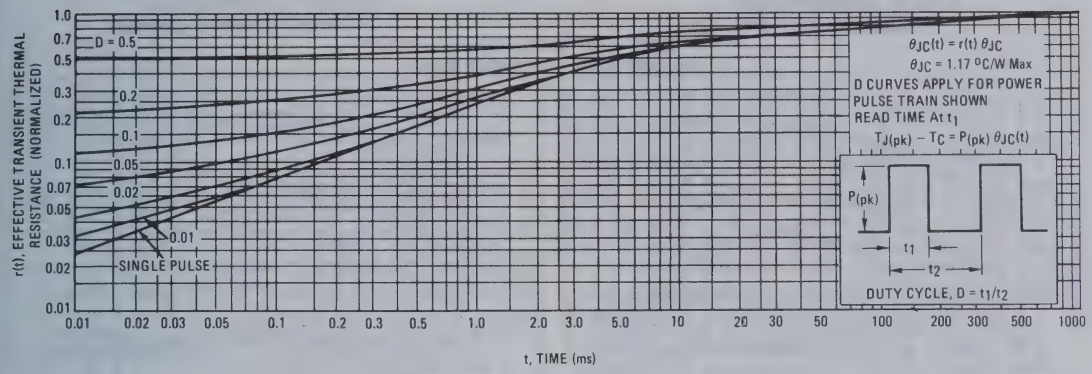


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – 2N6050, 2N6057

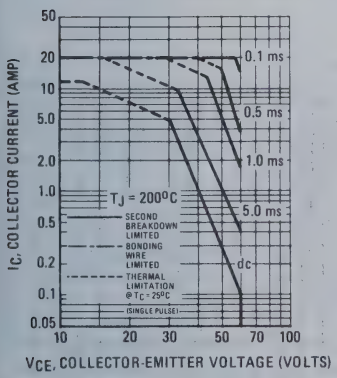


FIGURE 6 – 2N6051, 2N6058

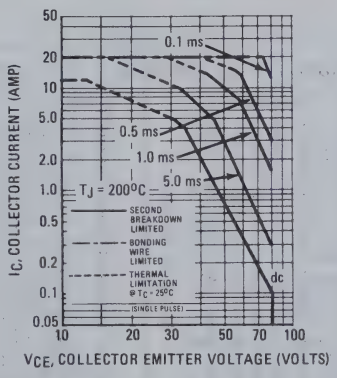
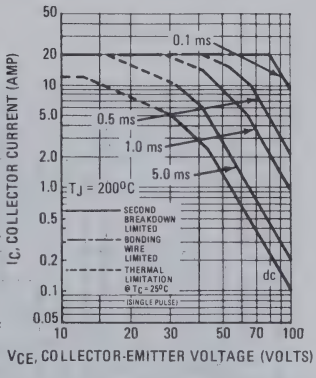


FIGURE 7 – 2N6052, 2N6059



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5, 6 and 7 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$ $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 8 – SMALL-SIGNAL CURRENT GAIN

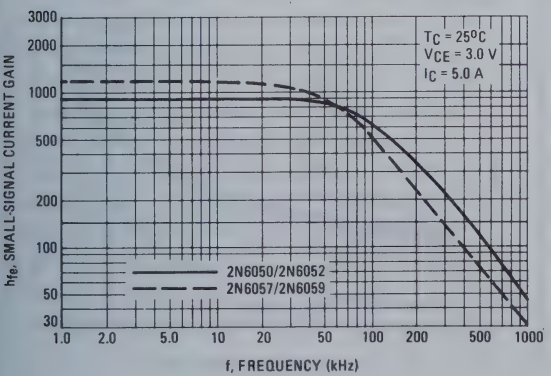
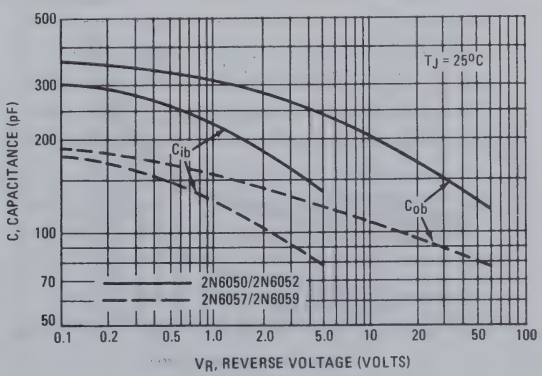


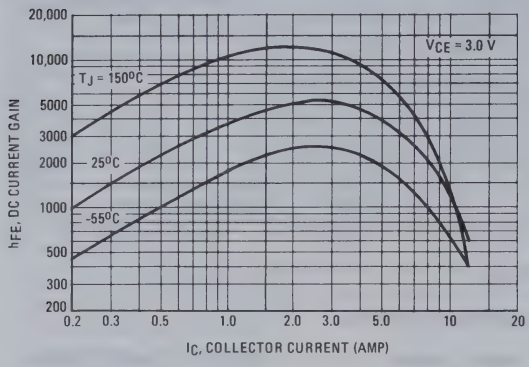
FIGURE 9 – CAPACITANCE



PNP
2N6050, 2N6051, 2N6052

NPN
2N6057, 2N6058, 2N6059

FIGURE 10 – DC CURRENT GAIN



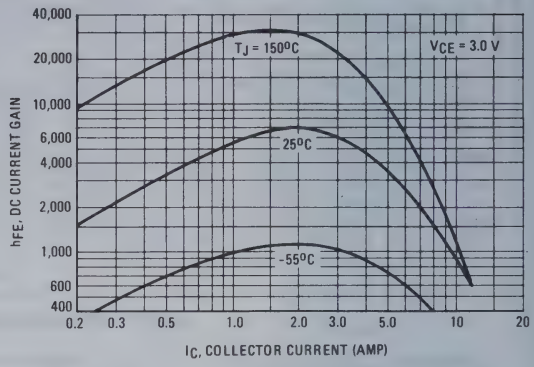
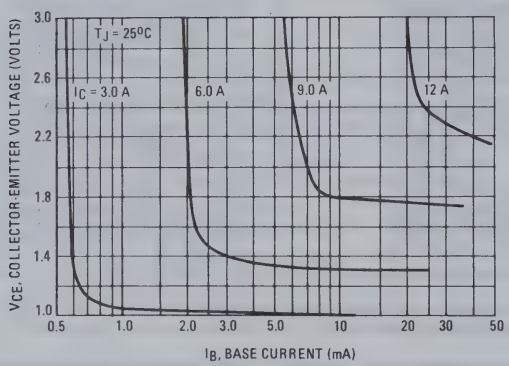


FIGURE 11 – COLLECTOR SATURATION REGION



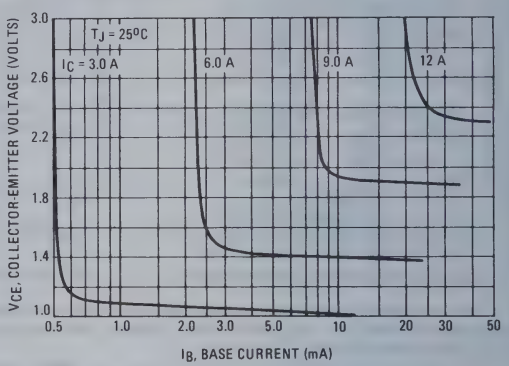
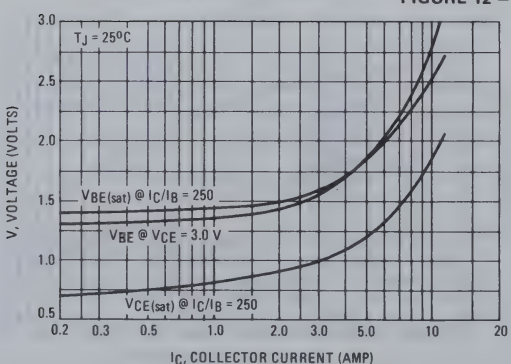
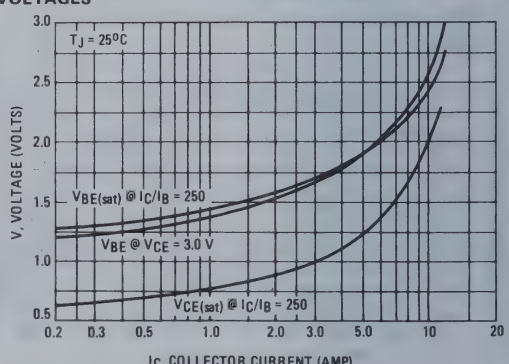


FIGURE 12 – "ON" VOLTAGES





PNP
2N6050, 2N6051, 2N6052

NPN
2N6057, 2N6058, 2N6059

FIGURE 13 – TEMPERATURE COEFFICIENTS

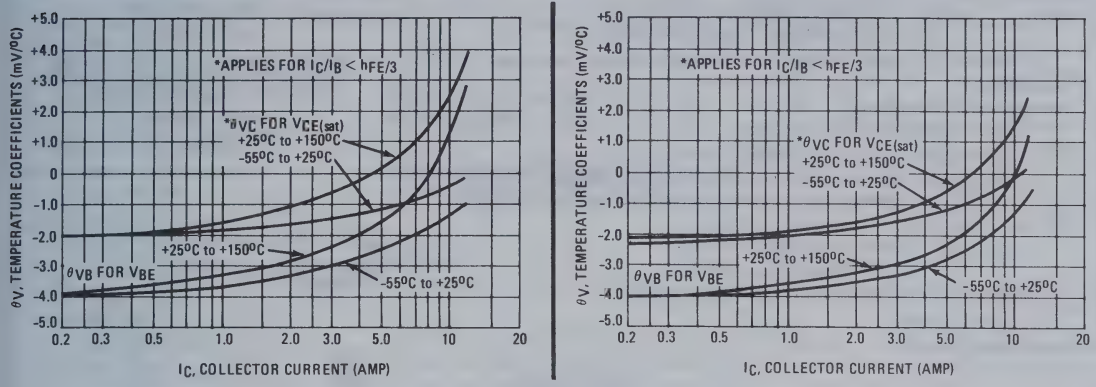


FIGURE 14 – COLLECTOR CUT-OFF REGION

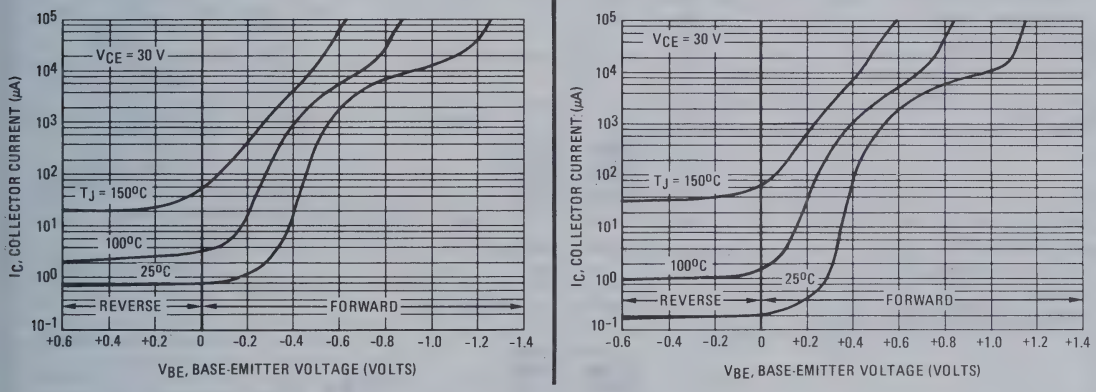
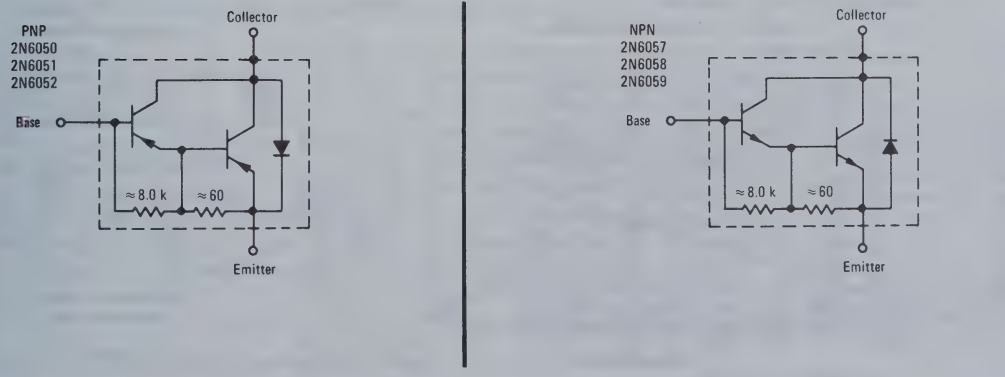


FIGURE 15 – DARLINGTON SCHEMATICS



2N6053, 2N6054, 2N6298, 2N6299 PNP (SILICON)

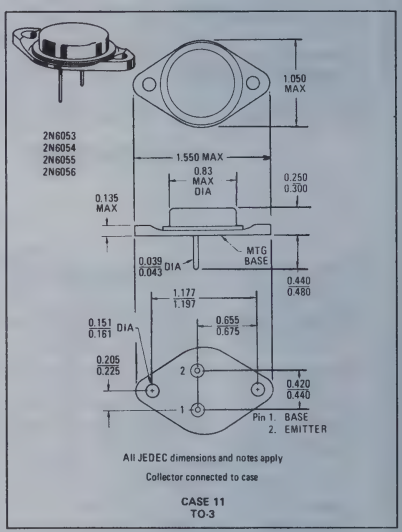
2N6055, 2N6056, 2N6300, 2N6301 NPN

DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain —
  h_{FE} = 3000 (Typ) @ I_C = 4.0 Adc
- Collector-Emitter Sustaining Voltage — @ 100 mA
  $V_{CEO(sus)}$ = 60 Vdc (Min) — 2N6053, 2N6055, 2N6298, 2N6300
  = 80 Vdc (Min) — 2N6054, 2N6056, 2N6299, 2N6301
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 2.0 Vdc (Max) @ I_C = 4.0 Adc
  = 3.0 Vdc (Max) @ I_C = 8.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

DARLINGTON 8 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS 60-80 VOLTS 75,100 WATTS



*MAXIMUM RATINGS

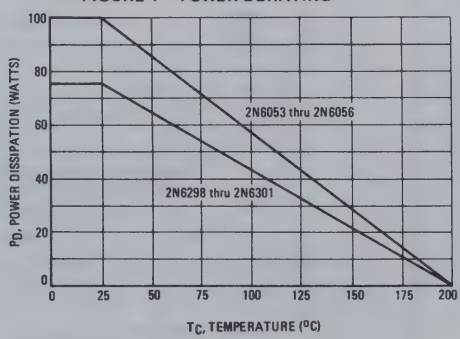
Rating	Symbol	2N6053 2N6055 2N6298 2N6300	2N6054 2N6056 2N6299 2N6301	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	8.0 16		Adc
Base Current	I_B	120		mAdc
		2N6053 2N6055 2N6056	2N6298 2N6299 2N6300 2N6301	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.571	75 0.428	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

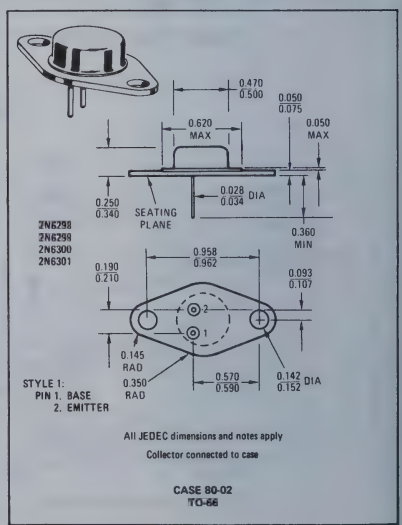
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N6053 2N6054 2N6055 2N6056	2N6298 2N6299 2N6300 2N6301	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.75	2.33	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER DERATING





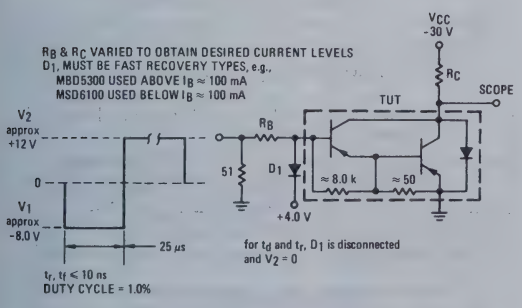
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N6053, 2N6055, 2N6298, 2N6300		60	–	
	2N6054, 2N6056, 2N6299, 2N6301		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N6053, 2N6055, 2N6298, 2N6300		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N6054, 2N6056, 2N6299, 2N6301		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	0.5	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C			–	5.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	2.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			750	18000	
(I_C = 8.0 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 16 mAdc)			–	2.0	
(I_C = 8.0 Adc, I_B = 80 mAdc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 80 mAdc)			–	4.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			–	2.8	
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short Circuit Current Transfer Ratio		$\lvert h_{fe} \rvert$			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)			4.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N6053, 2N6054, 2N6298, 2N6299		–	300	
	2N6055, 2N6056, 2N6300, 2N6301		–	200	
Small-Signal Current Gain		h_{fe}			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)			300	–	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0 %.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit reverse diode, polarities and input pulses.

FIGURE 3 – SWITCHING TIMES

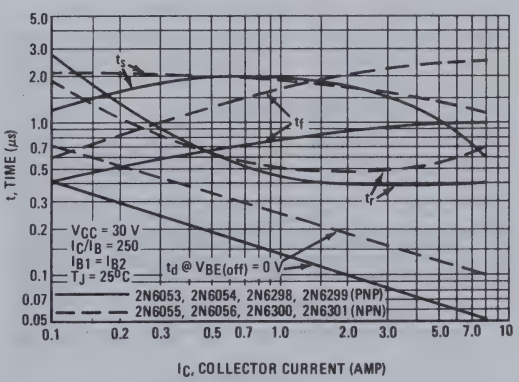
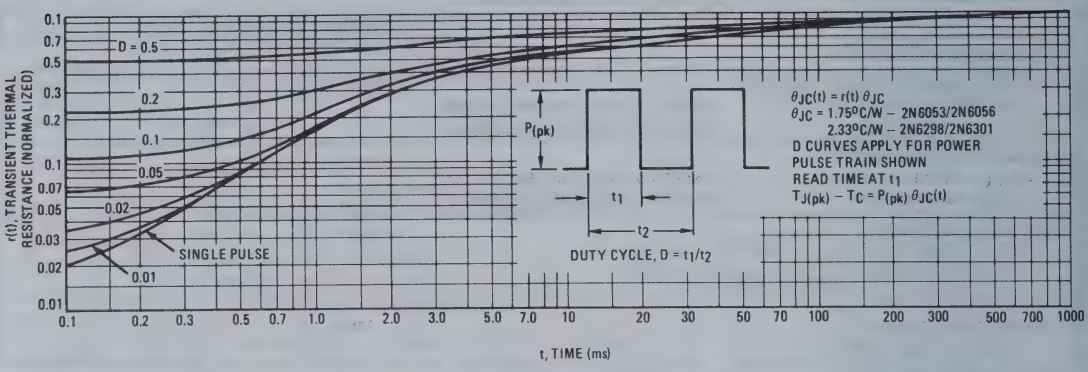


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – 2N6053 thru 2N6056

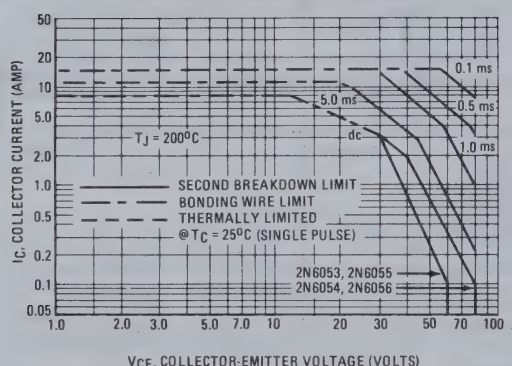
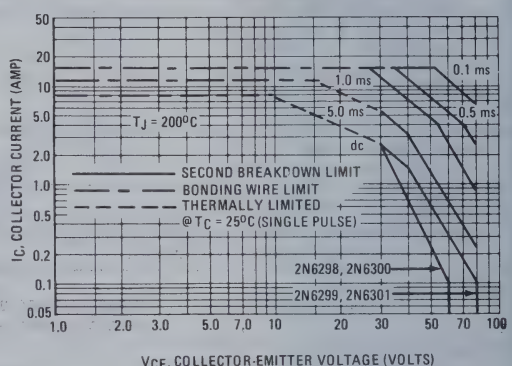


FIGURE 6 – 2N6298 thru 2N6301



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figures 5 and 6 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 7 – SMALL-SIGNAL CURRENT GAIN

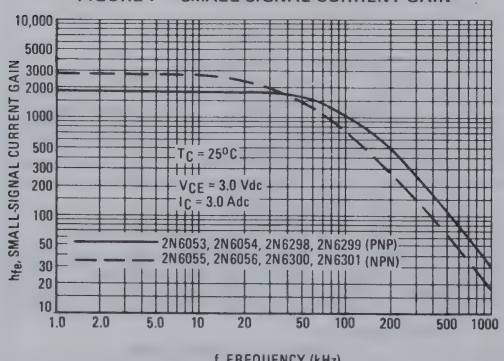
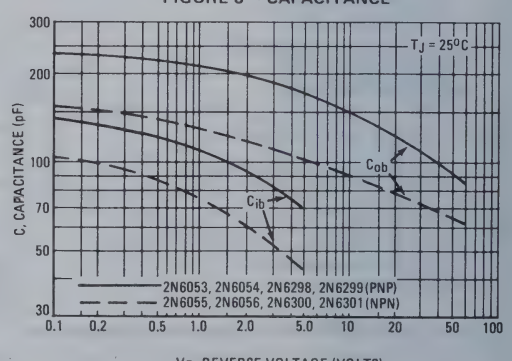


FIGURE 8 – CAPACITANCE



PNP

2N6053, 2N6054, 2N6298, 2N6299

NPN

2N6055, 2N6056, 2N6300, 2N6301

FIGURE 9 – DC CURRENT GAIN

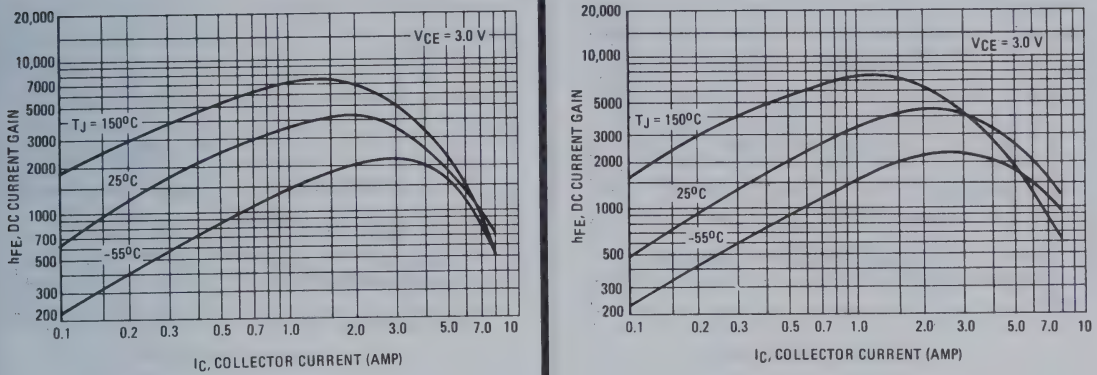


FIGURE 10 – COLLECTOR SATURATION REGION

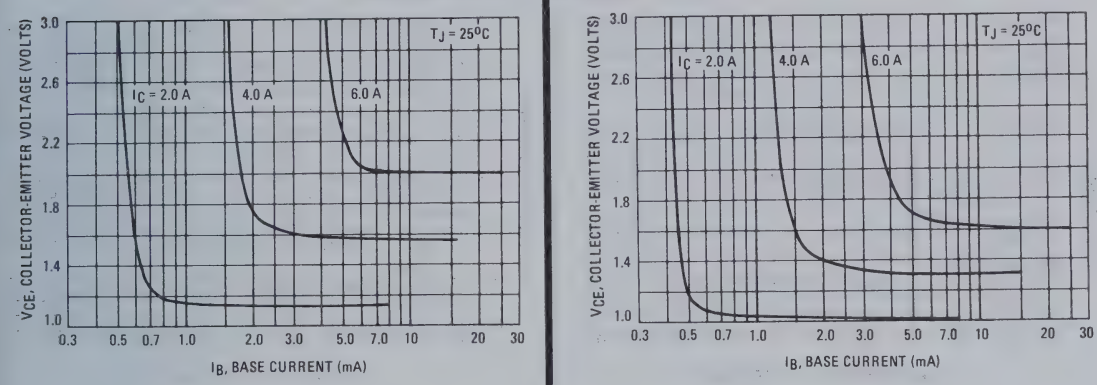
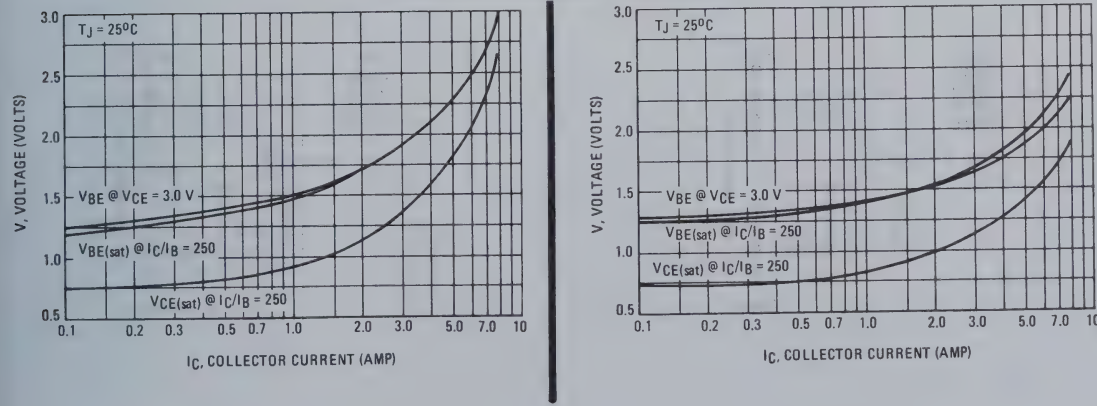


FIGURE 11 – "ON" VOLTAGES



PNP

2N6053, 2N6054, 2N6298, 2N6299

NPN

2N6055, 2N6056, 2N6300, 2N6301

FIGURE 12 – TEMPERATURE COEFFICIENTS

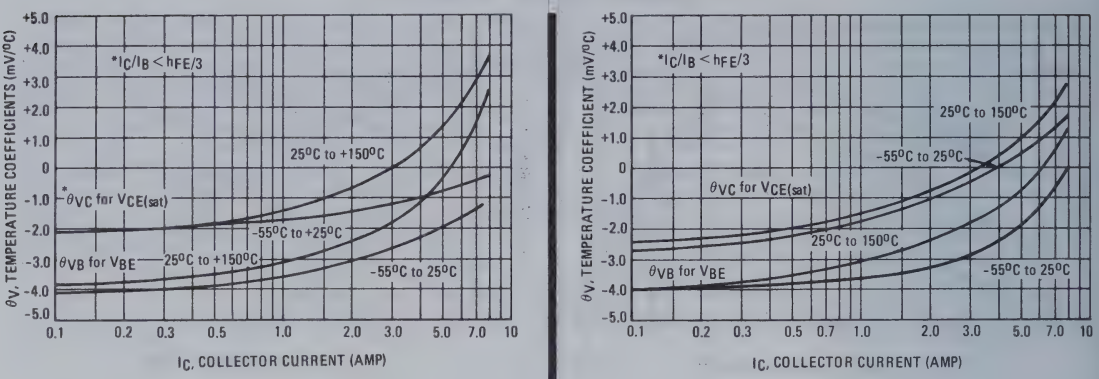


FIGURE 13 – COLLECTOR CUT-OFF REGION

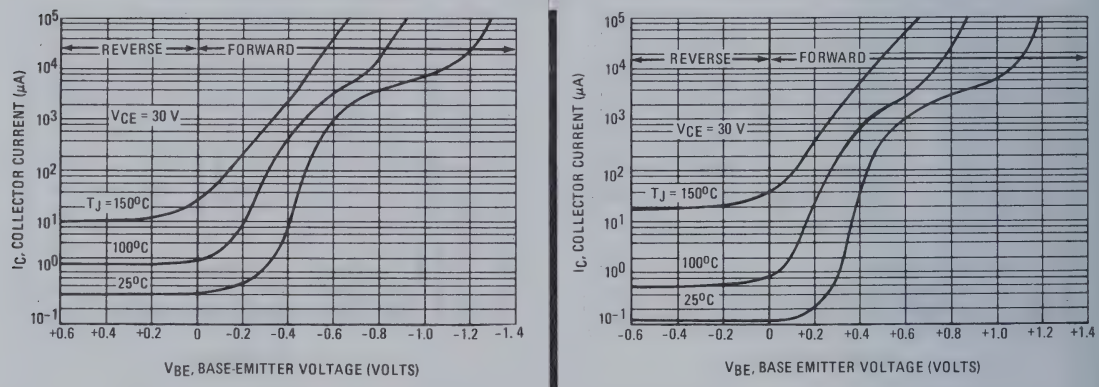


FIGURE 14 – DARLINGTON SCHEMATIC



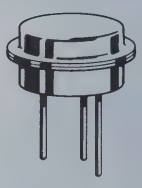
2N6064 (GERMANIUM)
2N6065
2N6066

PNP GERMANIUM POWER TRANSISTORS

. . . designed for high-voltage switching applications.

- Low Leakage Current – I_{CBO} = 3.0 mAdc (Max)
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 10 Adc
- Switching Times – t_{on} = 10 μs @ 3.0 Adc
  t_{off} = 15 μs @ 3.0 Adc

10 AMPERE POWER TRANSISTORS
PNP GERMANIUM ALLOY DIFFUSED
80–120–160 VOLTS
56 WATTS



*MAXIMUM RATINGS

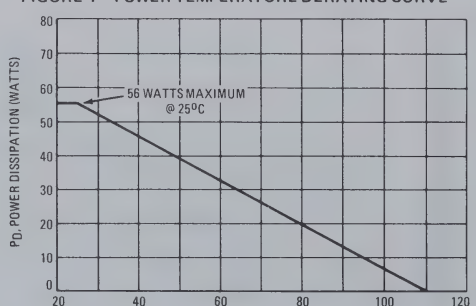
Rating	Symbol	2N6064	2N6065	2N6066	Unit
Collector-Emitter Voltage	V_{CEO}	80	120	160	Vdc
Collector-Base Voltage	V_{CB}	80	120	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	10			Adc
Base Current	I_B	5.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	56 0.67			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +110			°C

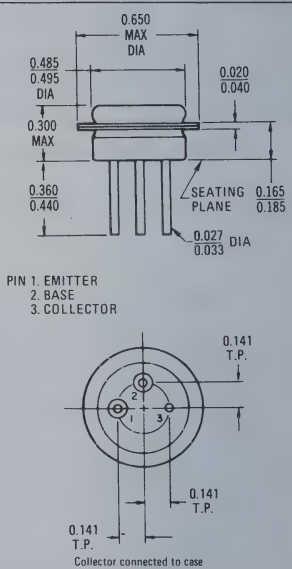
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.50	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





To convert inches to millimeters multiply by 25.4

CASE 8

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N6064		80	–	
	2N6065		120	–	
	2N6066		160	–	
Emitter Floating Potential		V_{EBF}			Vdc
(V_{CE} = 80 Vdc, I_B = 0)	2N6064		–	1.0	
(V_{CE} = 120 Vdc, I_B = 0)	2N6065		–	1.0	
(V_{CE} = 160 Vdc, I_B = 0)	2N6066		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +100°C)	2N6064		–	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +100°C)	2N6065		–	35	
(V_{CE} = 160 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +100°C)	2N6066		–	35	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N6064		–	3.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N6065		–	3.0	
(V_{CB} = 160 Vdc, I_E = 0)	2N6066		–	3.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	50	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	50	–
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12 Vdc)		f_T	300	–	kHz
SWITCHING CHARACTERISTICS (SEE FIGURE 8)					
Turn-On Time (I_C = 3.0 Adc, I_{B1} = 0.3 Adc, V_{CC} = 30 Vdc)		t_{on}	–	10	μs
Turn-Off Time (I_C = 3.0 Adc, I_{B1} = I_{B2} = 0.3 Adc, V_{CC} = 30 Vdc)		t_{off}	–	15	μs

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

*Indicates JEDEC Registered Data.

FIGURE 2 – THERMAL RESPONSE

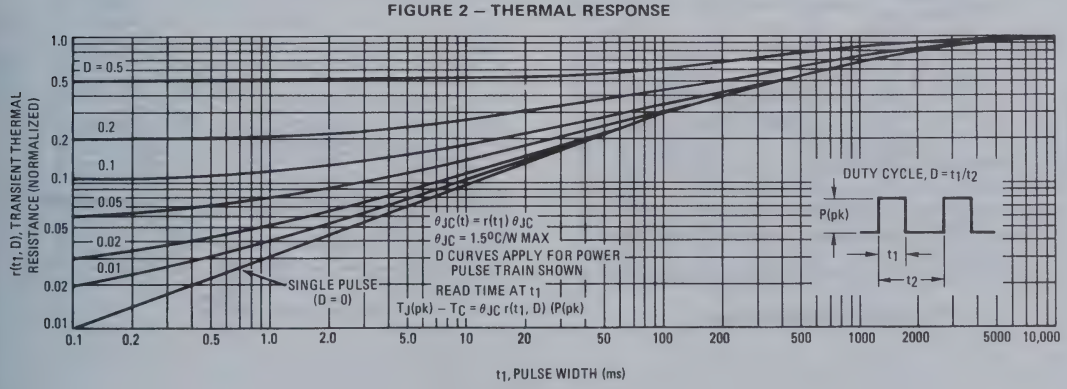


FIGURE 3 – CLAMPED INDUCTIVE SAFE OPERATING AREA

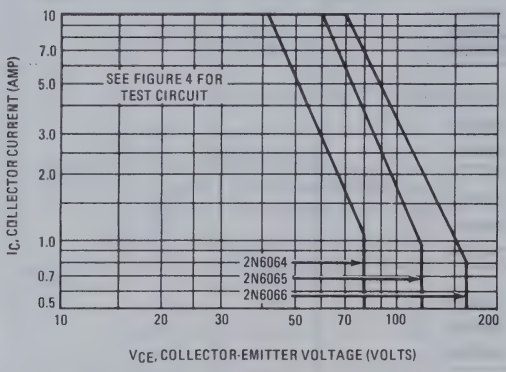


FIGURE 4 – CLAMPED INDUCTIVE TEST CIRCUIT

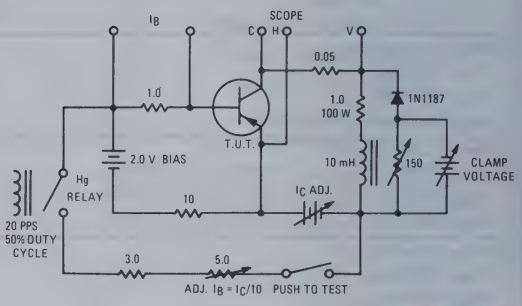


FIGURE 5 – ACTIVE-REGION SAFE-OPERATING AREA

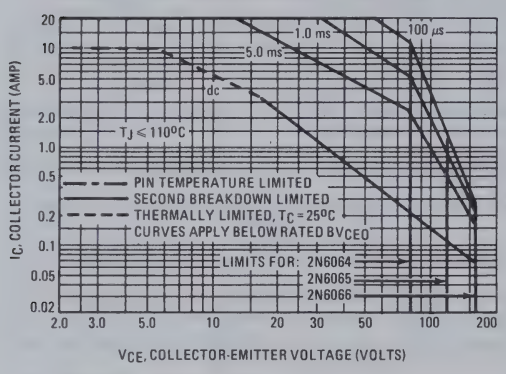


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

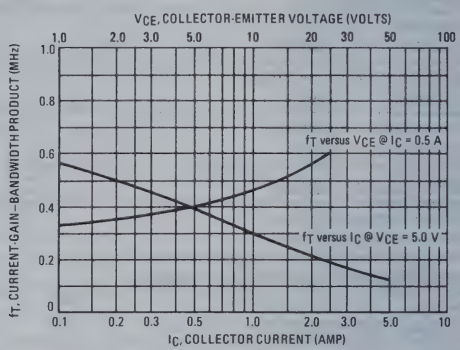


FIGURE 7 – SWITCHING TIMES

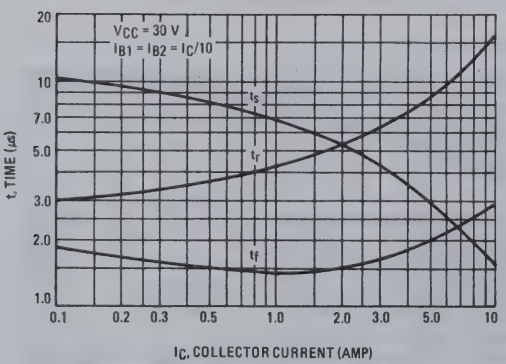


FIGURE 8 – SWITCHING TIMES TEST CIRCUIT

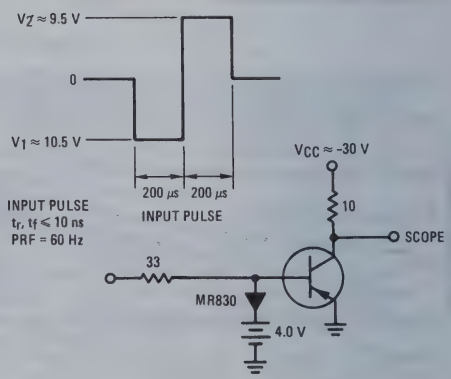


FIGURE 9 – DC CURRENT GAIN

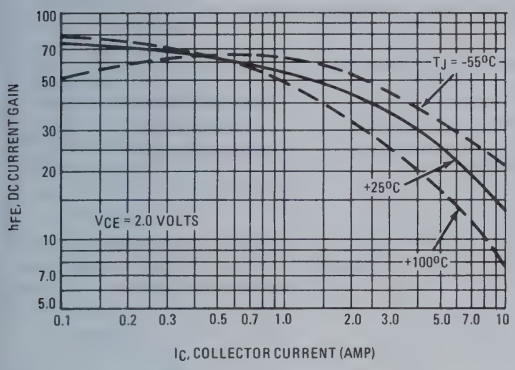


FIGURE 10 – COLLECTOR SATURATION REGION

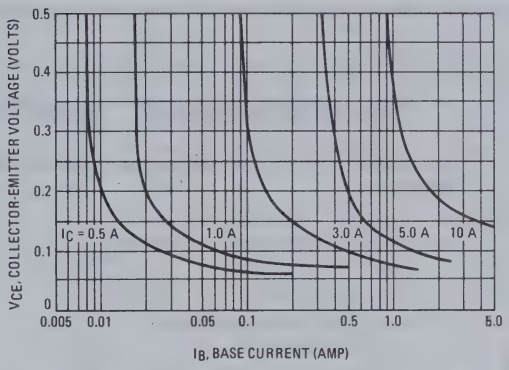


FIGURE 11 – "ON" VOLTAGES

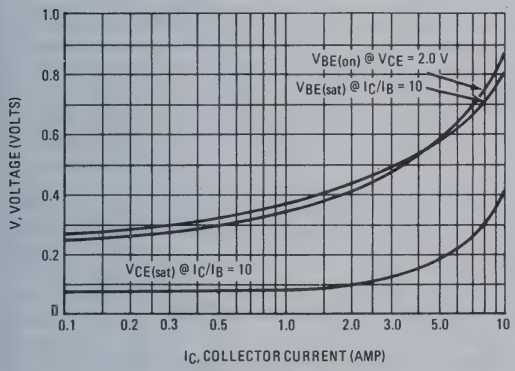


FIGURE 12 – TEMPERATURE COEFFICIENTS

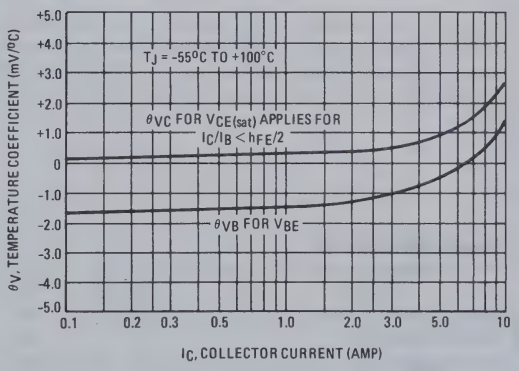


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE

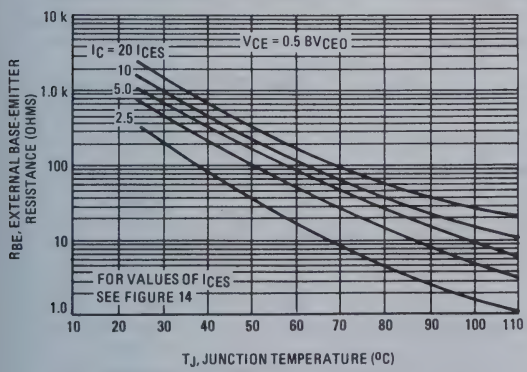
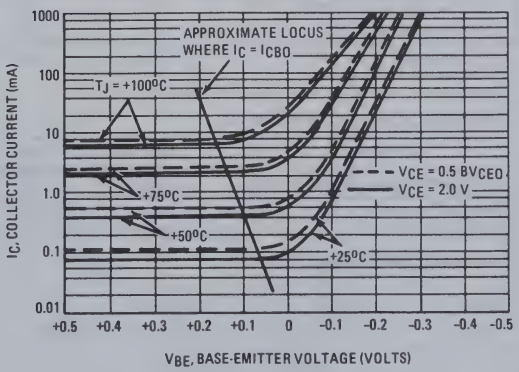


FIGURE 14 – COLLECTOR CUTOFF REGION



2N6067 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for medium-current saturated switching and core driver applications.

- Fast Switching Times @ V_{CC} = 40 Vdc –
  t_{on} = 40 ns (Max)
  t_{off} = 80 ns (Max)
- Current-Gain–Bandwidth Product –
  f_T = 150 MHz (Min)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 500 mAdc

PNP SILICON SWITCHING TRANSISTOR



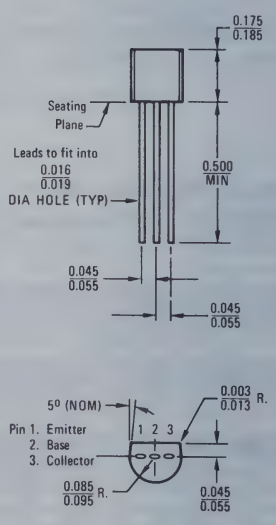
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

*Indicates JEDEC Registered Data.



CASE 29 (1)
TO-92

2N6067 (continued)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

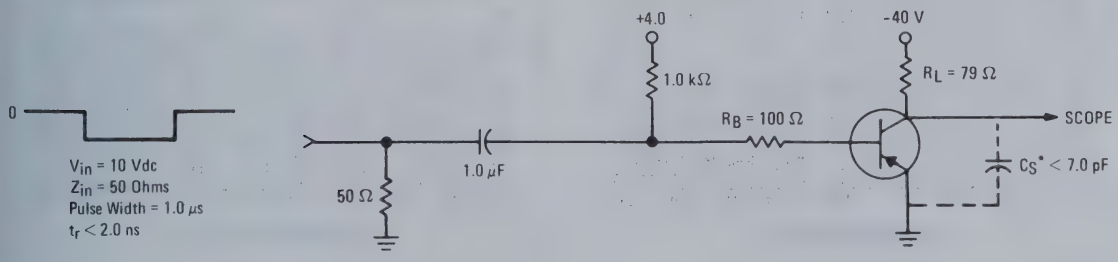
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ① (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	500	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ①	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	200	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		25	150	
Collector-Emitter Saturation Voltage ①	$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	0.6	
Base-Emitter Saturation Voltage ①	$V_{BE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.9	
(I_C = 500 mAdc, I_B = 50 mAdc)		0.8	1.1	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ② (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	16	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	–	80	pF
SWITCHING CHARACTERISTICS				
Turn-On Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{EB(off)}$ = 4.0 Vdc)	t_{on}	–	40 ns
Delay Time		t_d	–	17 ns
Rise Time		t_r	–	28 ns
Turn-Off Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	80 ns
Storage Time		t_s	–	70 ns
Fall Time		t_f	–	25 ns

*Indicates JEDEC Registered Data.

① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

② f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 2 – DELAY TIME

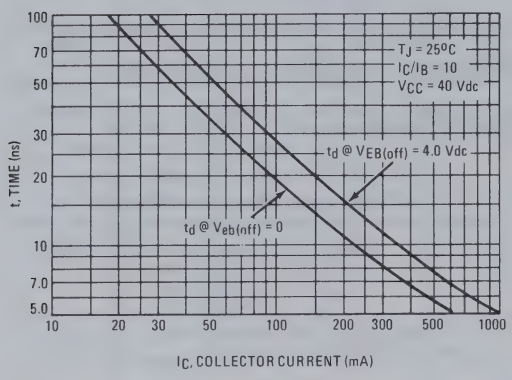


FIGURE 3 – RISE TIME

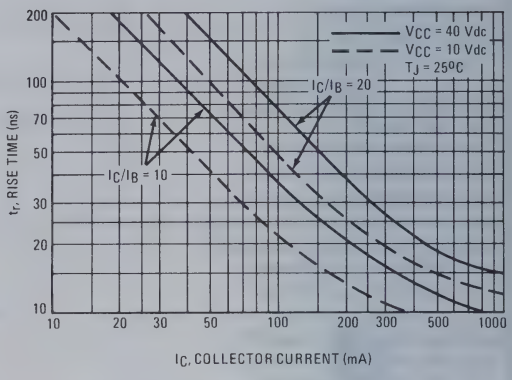


FIGURE 4 – STORAGE TIME

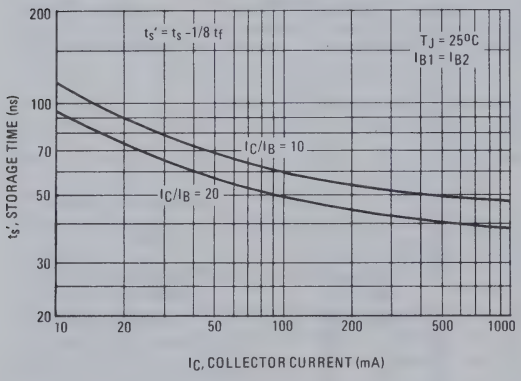


FIGURE 5 – STORAGE TIME

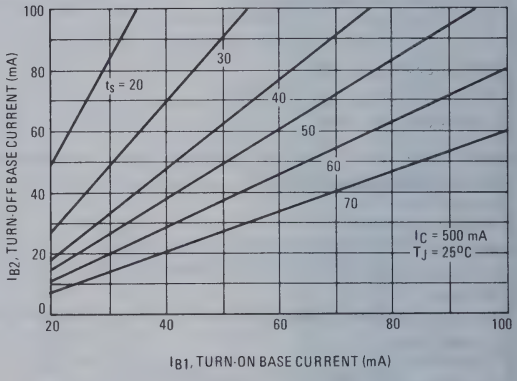


FIGURE 6 – FALL TIME

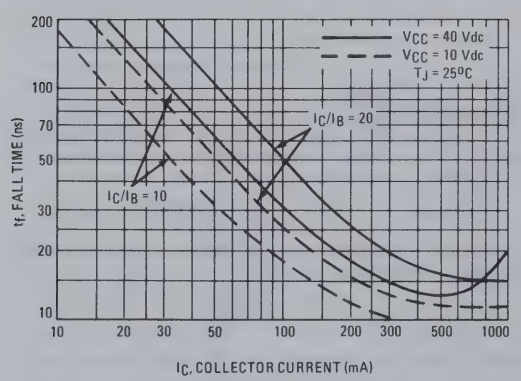
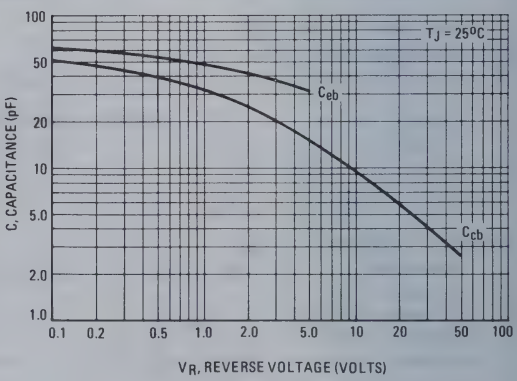


FIGURE 7 – CAPACITANCES



TYPICAL STATIC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

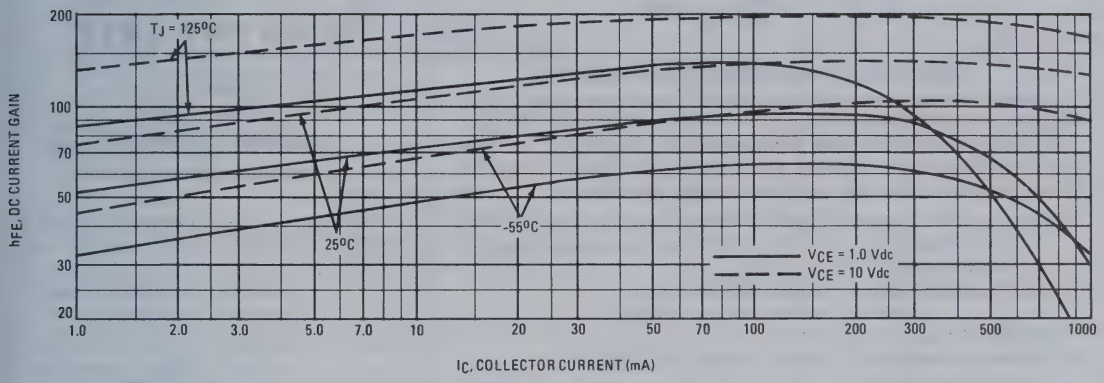


FIGURE 9 – SATURATION REGION

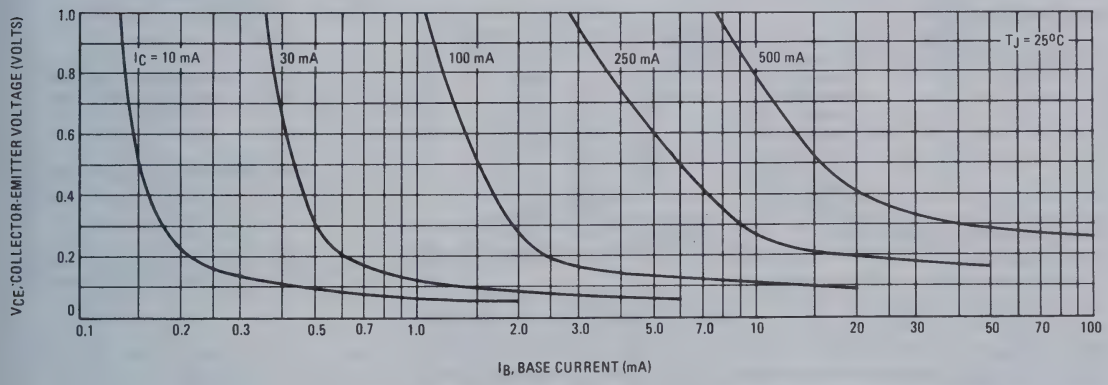


FIGURE 10 – "ON" VOLTAGES

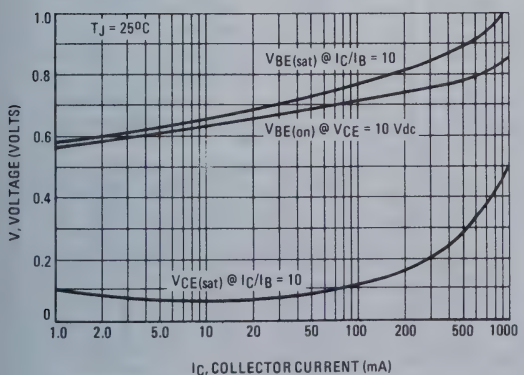
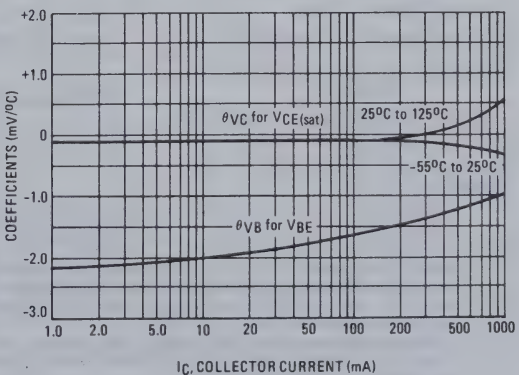


FIGURE 11 – TEMPERATURE COEFFICIENTS



2N6068,A,B (SILICON)
thru
2N6075,A,B



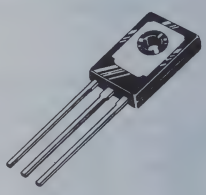
SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Sensitive Gate Triggering (A and B versions) Uniquely Compatible for Direct Coupling to TTL, HTL, CMOS and Operational Amplifier Integrated Circuit Logic Functions.
- Gate Triggering 2 Mode – 2N6068 thru 2N6075
  4 Mode – 2N6068A,B thru 2N6075A,B
- Blocking Voltages to 600 Volts
- All Diffused and Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability

SENSITIVE GATE

TRIACS
(THYRISTORS)
4 AMPERES RMS
25 THRU 600 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage, Note 1 (T_J = 110°C) 2N6068,A,B	V_{DRM}	25	Volts
2N6069,A,B		50	
2N6070,A,B		100	
2N6071,A,B		200	
2N6072,A,B		300	
2N6073,A,B		400	
2N6074,A,B		500	
2N6075,A,B		600	
*On-State Current RMS (T_C = 85°C)	$I_{T(RMS)}$	4.0	Amp
*Peak Surge Current (One Full cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	30	Amp
Circuit Fusing Considerations (T_J = -40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	3.6	A^2s
*Peak Gate Power	P_{GM}	10	Watts
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Gate Voltage	V_{GM}	5.0	Volts
*Operating Junction Temperature Range	T_J	-40 to +110	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 Screw), Note 2	—	8.0	in. lb.

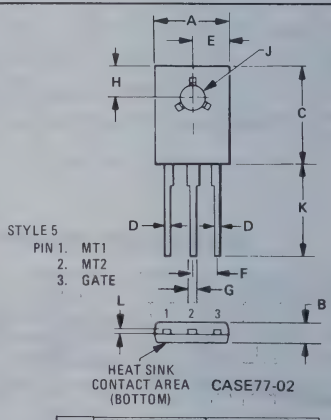
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R\theta_{JC}$	3.5	°C/W
Thermal Resistance, Case to Ambient	$R\theta_{CA}$	60	°C/W

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Main terminal 2 and heat-sink contact pad are common.
   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +200°C, for 10 seconds. Consult factory for lead bending options.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.860	8.380	0.270	0.330
B	1.770	3.300	0.070	0.130
C	9.910	11.430	0.390	0.450
D	0.508	0.660	0.020	0.026
E	3.810 NOM		0.150 NOM	
F	2.290 TP		0.090 TP	
G	0.635	0.889	0.025	0.035
H	3.300	4.450	0.130	0.175
J	2.910	3.000	0.115	0.118
K	15.110	16.650	0.595	0.655
L	0.381	0.635	0.015	0.025

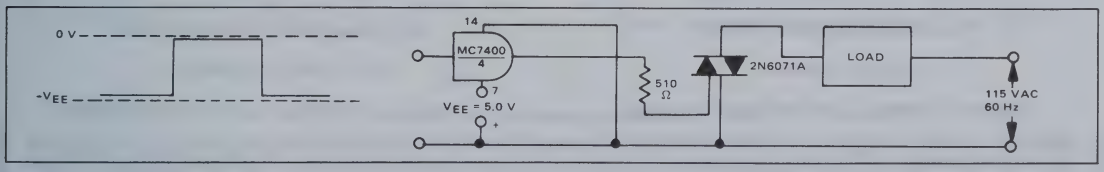
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

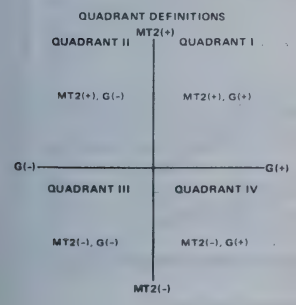
Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C, Gate Open	I_{DRM}	–	–	2.0	mA
*On-State Voltage (Either Direction) I_{TM} = 6.0 A Peak	V_{TM}	–	–	2.0	Volts
*Peak Gate Trigger Voltage Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms, T_J = –40°C	V_{GTM}				Volts
MT2 (+), G(+); MT2 (–), G(–) All Types		–	1.4	2.5	
MT2 (+), G(–); MT2 (–), G(+) 2N6068A,B thru 2N6075A,B		–	1.4	2.5	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 110°C					
MT2 (+), G(+); MT2 (–), G(–) All Types		0.2	–	–	
MT2 (+), G(–); MT2 (–), G(+) 2N6068A,B thru 2N6075A,B		0.2	–	–	
*Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, T_J = –40°C Initiating Current = 1.0 Adc	I_H				mA
2N6068 thru 2N6075		–	–	70	
2N6068A,B thru 2N6075A,B		–	–	30	
T_J = 25°C 2N6068 thru 2N6075		–	–	30	
2N6068A,B thru 2N6075A,B		–	–	15	
Turn-On Time (Either Direction) I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{on}	–	1.5	–	μs
Blocking Voltage Application Rate at Commutation @ V_{DRM}, T_J = 85°C, Gate Open	dv/dt	–	5.0	–	V/μs

	Type	I_{GTM} @ T_J	QUADRANT (See Definition Below) I mA	II mA	III mA	IV mA
*Peak Gate Trigger Current Main Terminal Voltage = 12 Vdc, R_L = 100 ohms	2N6068 thru 2N6075	+25°C	30	–	30	–
		-40°C	60	–	60	–
Maximum Value	2N6068A thru 2N6075A	+25°C	5.0	5.0	5.0	10
		-40°C	20	20	20	30
	2N6068B thru 2N6075B	+25°C	3.0	3.0	3.0	5.0
		-40°C	15	15	15	20

*Indicates JEDEC Registered Data.

SAMPLE APPLICATION:
TTL-SENSITIVE GATE 4 AMPERE TRIAC
TRIGGERS IN MODES II AND III





Trigger devices are recommended for gating on Triacs. They provide

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

For 2N6068 Thru 2N6075

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	30 – 50 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches

SENSITIVE GATE LOGIC REFERENCE

IC LOGIC FUNCTIONS	FIRING QUADRANT I	II	III	IV
TTL		2N6068A Series	2N6068A Series	
HTL		2N6068A Series	2N6068A Series	
McMOS (NAND)	2N6068B Series			2N6068B Series
McMOS (Buffer)		2N6068B Series	2N6068B Series	
Operational Amplifier	2N6068A Series			2N6068A Series
Zero Voltage Switch		2N6068A Series	2N6068A Series	

FIGURE 1 – AVERAGE CURRENT DERATING

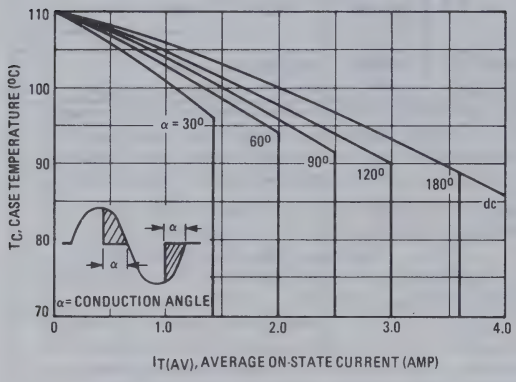


FIGURE 2 – RMS CURRENT DERATING

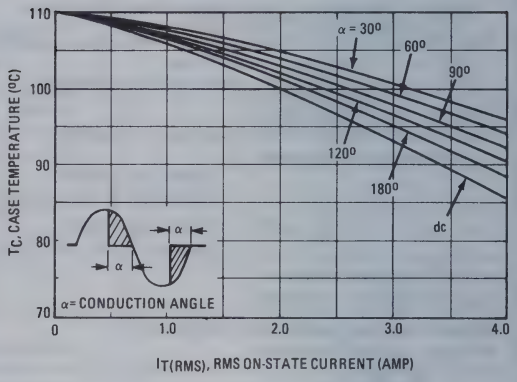


FIGURE 3 – POWER DISSIPATION

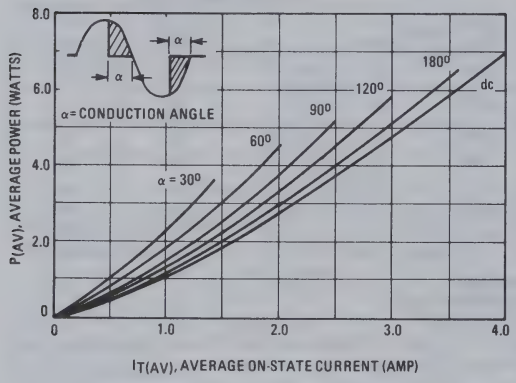


FIGURE 4 – POWER DISSIPATION

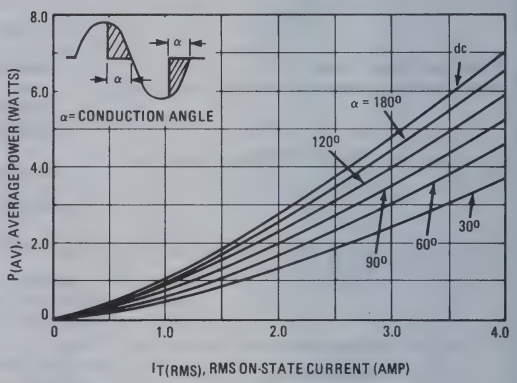


FIGURE 5 – TYPICAL GATE-TRIGGER VOLTAGE

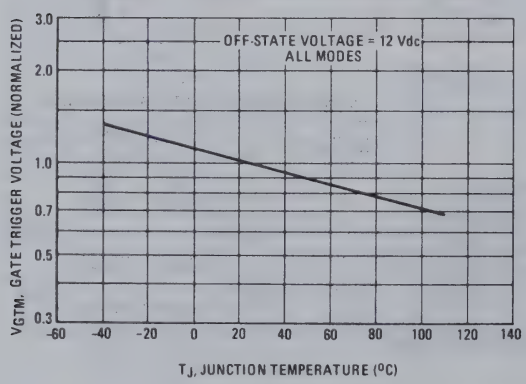


FIGURE 6 – TYPICAL GATE-TRIGGER CURRENT

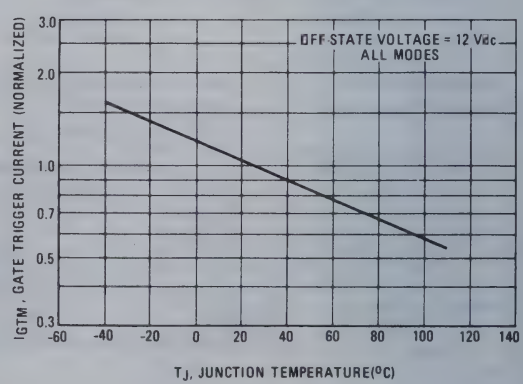


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

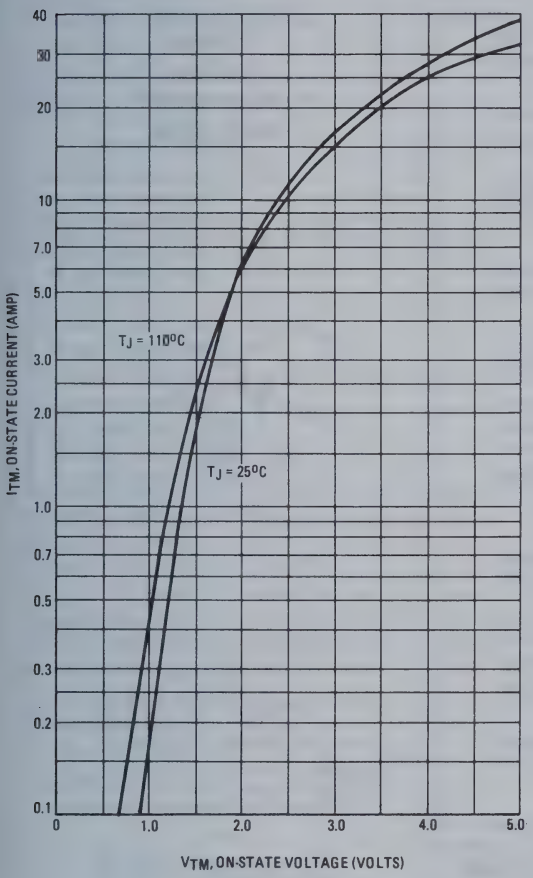


FIGURE 8 – TYPICAL HOLDING CURRENT

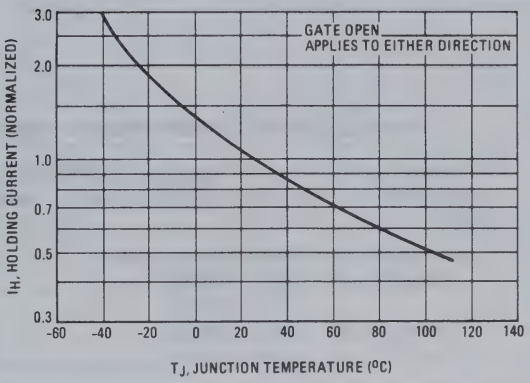


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

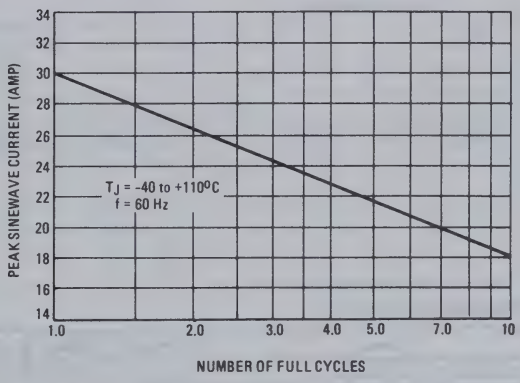
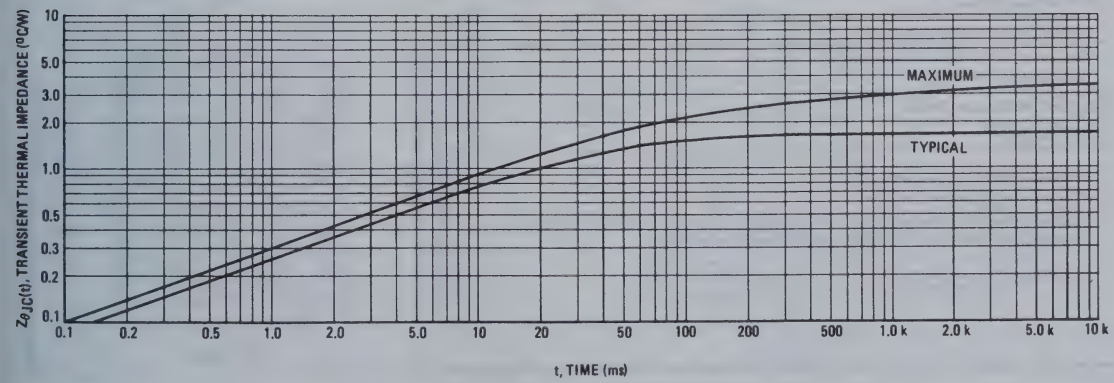


FIGURE 10 – THERMAL RESPONSE



2N6080 (SILICON)
2N6081

The RF Line

NPN SILICON RF POWER TRANSISTORS

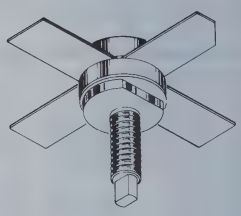
. . . designed for 12.5 Volt VHF large-signal power amplifier applications required in military and industrial equipment operating to 300 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 4.0 W – 2N6080
  15 W – 2N6081
  Minimum Gain = 12 dB – 2N6080
  6.3 dB – 2N6081
- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch
- Stripline Packaging for lower lead inductance and better broadband capability

4.0 and 15 W
175 MHz

RF POWER TRANSISTORS

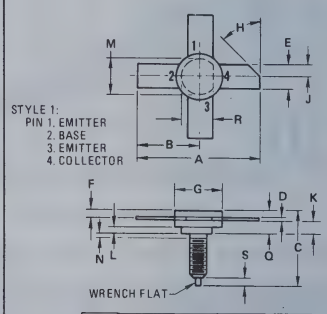
NPN SILICON



***MAXIMUM RATINGS**

Rating	Symbol	2N6080	2N6081	Unit
Collector-Emitter Voltage	V_{CEO}	18		Vdc
Collector-Base Voltage	V_{CBO}	36		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current – Continuous	I_C	1.0	2.5	Adc
Total Device Dissipation @ T_C = 25°C (2) Derate above 25°C	P_D	12 68.5	31 177	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Stud Torque(1)	–	6.5		in. lb.

*Indicates JEDEC Registered Data
(1) For repeated assembly use 5 in. lb.
(2) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	26.79	27.05	1.055	1.065
B	13.20	13.71	.520	.530
C	18.03	19.05	.710	.750
D	.114	.152	.0045	.006
E	5.59	5.84	.220	.230
F	2.16	2.41	.085	.095
G	9.40	9.78	.370	.385
H	45° NOM		45° NOM	
J	2.79	2.93	.110	.115
K	4.01	4.52	.158	.178
L	1.78	2.03	.070	.080
M	8.13	8.38	.320	.330
N	–	1.27	–	.050
Q	6.35	6.89	.250	.275
R	7.59	7.80	.299	.307
S	2.54	3.30	.100	.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	2N6080		18	–	–	
(I_C = 20 mAdc, I_B = 0)	2N6081		18	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 5.0 mAdc, V_{BE} = 0)	2N6080		36	–	–	
(I_C = 10 mAdc, V_{BE} = 0)	2N6081		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N6080		4.0	–	–	
(I_E = 2.0 mAdc, I_C = 0)	2N6081		4.0	–	–	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_C = +55°C)	2N6080		–	–	5.0	
	2N6081		–	–	8.0	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N6080		–	–	0.25	
	2N6081		–	–	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 0.25 Adc, V_{CE} = 5.0 Vdc)	2N6080		5.0	–	–	
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	2N6081		5.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	2N6080		–	15	20	
	2N6081		–	70	85	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6080		12	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6081		6.3	–	–	
Collector Efficiency		η				%
(P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6080		50	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6081		60	–	–	

*Indicates JEDEC Registered Data

175 MHz TEST CIRCUIT

FIGURE 1 – 2N6080

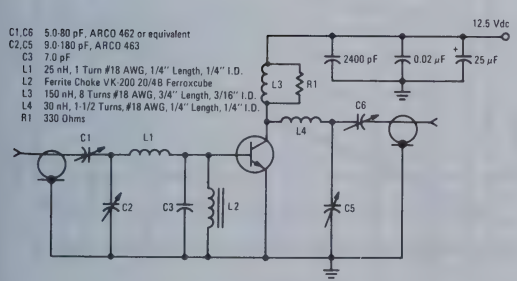
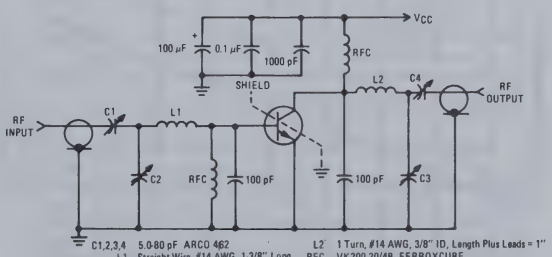


FIGURE 2 – 2N6081



OUTPUT POWER versus INPUT POWER

FIGURE 3 – 2N6080

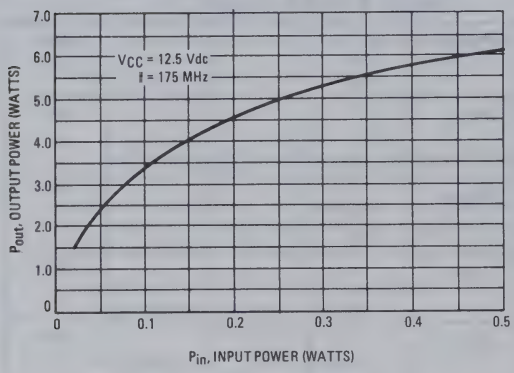
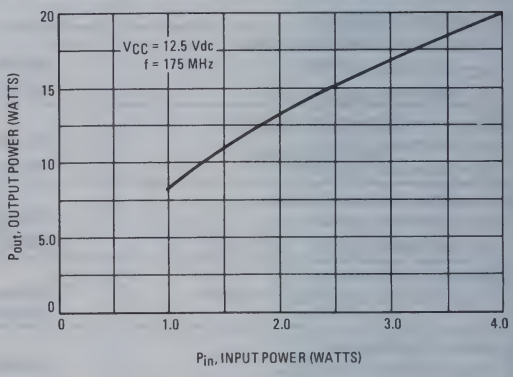


FIGURE 4 – 2N6081



OUTPUT POWER versus FREQUENCY

FIGURE 5 – 2N6080

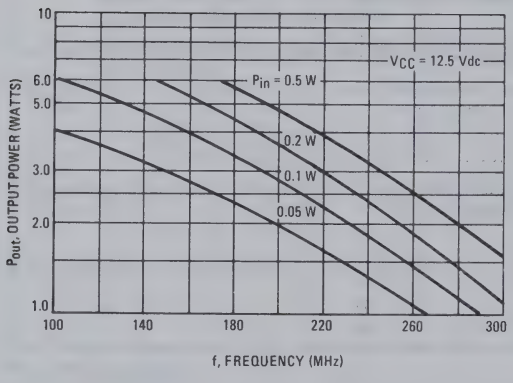
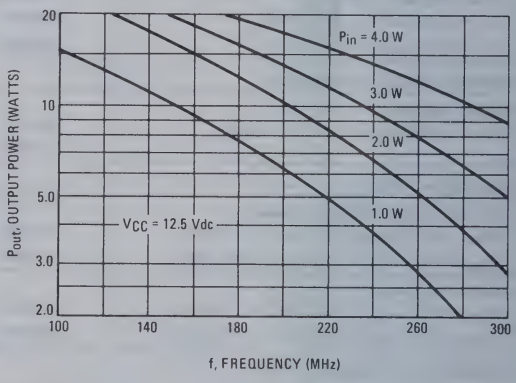


FIGURE 6 – 2N6081



OUTPUT POWER versus SUPPLY VOLTAGE

FIGURE 7 – 2N6080

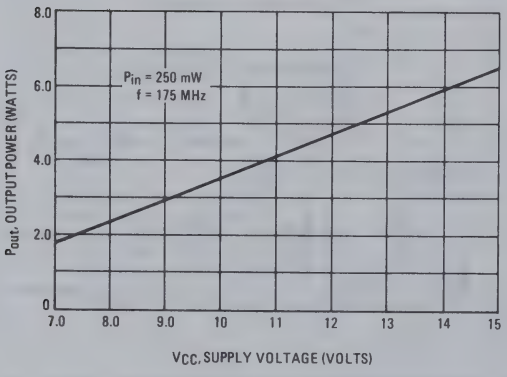
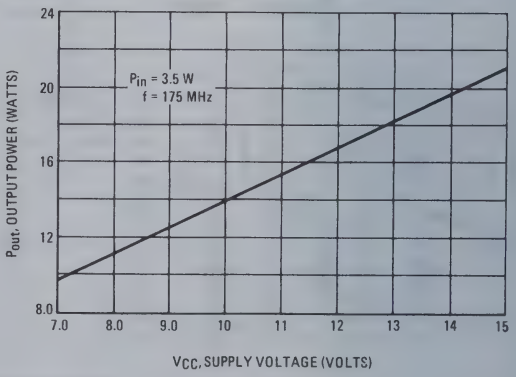


FIGURE 8 – 2N6081



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 9 – 2N6080

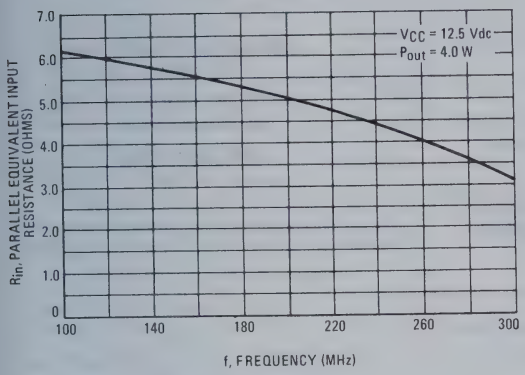
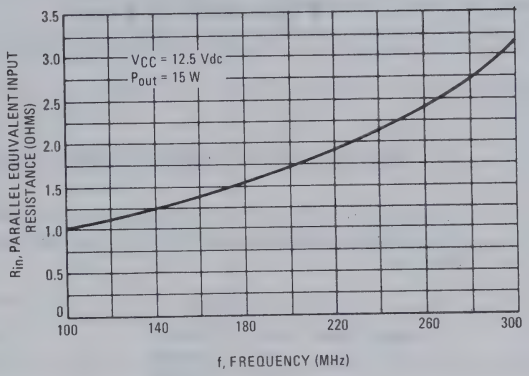


FIGURE 10 – 2N6081



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 11 – 2N6080

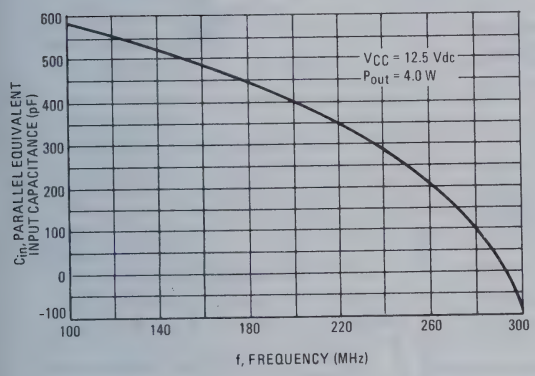
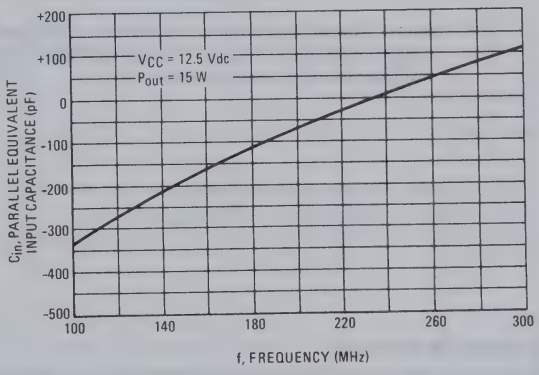


FIGURE 12 – 2N6081



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 13 – 2N6080

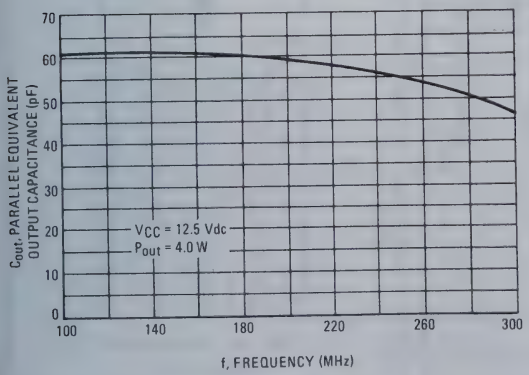
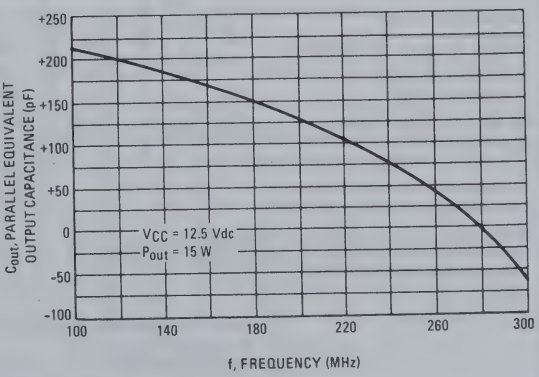


FIGURE 14 – 2N6081



2N6082, 2N6083, 2N6084 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

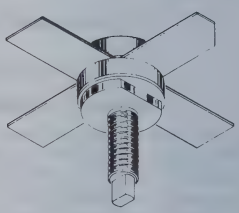
. . . designed for 12.5 Volt VHF large-signal power amplifier applications required in military and industrial equipment operating to 225 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 25 W – 2N6082
  30 W – 2N6083
  40 W – 2N6084
  Minimum Gain = 6.2 dB – 2N6082
  5.7 dB – 2N6083
  4.5 dB – 2N6084
- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch

25, 30 and 40 W
175 MHz

RF POWER TRANSISTORS

NPN SILICON



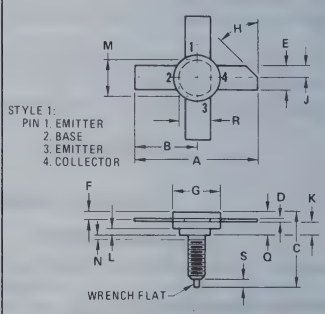
***MAXIMUM RATINGS**

Rating	Symbol	2N6082 2N6083	2N6084	Unit
Collector-Emitter Voltage	V_{CEO}	18		Vdc
Collector-Base Voltage	V_{CBO}	36		Vdc
Emitter-Base Voltage	V_{EBO}	4.0		Vdc
Collector Current – Continuous	I_C	4.0	6.0	Adc
Total Device Dissipation @ $T_C = 75^oC$(2) Derate above 25^oC	P_D	65 0.52	80 0.64	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200		^oC
Stud Torque(1)	–	6.5		in. lb.

*Indicates JEDEC Registered Data

(1) For Repeated Assembly Use 5 in. lb.

(2) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	26.79	27.05	1.055	1.065
B	13.20	13.71	.520	.530
C	18.03	19.05	.710	.750
D	.114	.152	.0045	.006
E	5.59	5.84	.220	.230
F	2.16	2.41	.085	.095
G	9.40	9.78	.370	.385
H	45° NOM		45° NOM	
J	2.79	2.93	.110	.115
K	4.01	4.52	.158	.178
L	1.78	2.03	.070	.080
M	8.13	8.38	.320	.330
N	–	1.27	–	.050
Q	6.35	6.89	.250	.275
R	7.59	7.80	.299	.307
S	2.54	3.30	.100	.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

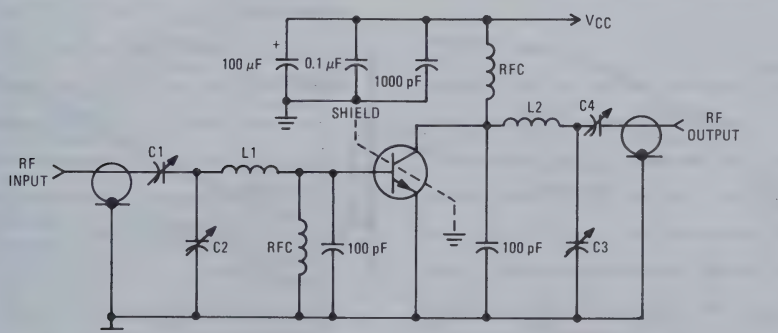
CASE 145A-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)		BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 15 mAdc, V_{BE} = 0)	2N6082,2N6083		36	–	–	
(I_C = 20 mAdc, V_{BE} = 0)	2N6084		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 5.0 mAdc, I_C = 0)	2N6082,2N6083		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N6084		4.0	–	–	
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = +55°C)		I_{CES}	–	–	10	mAdc
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N6082,2N6083		–	–	1.0	
	2N6084		–	–	2.5	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	2N6082,2N6083		–	110	130	
	2N6084		–	170	200	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6082		6.2	–	–	
(P_{out} = 30 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6083		5.7	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6084		4.5	–	–	
Collector Efficiency		η				%
(P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6082		65	–	–	
(P_{out} = 30 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6083		65	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6084		70	–	–	

*Indicates JEDEC Registered Data

FIGURE 1 – 175 MHz TEST CIRCUIT



C1,2,3,4 5.0-80 pF ARCO 462
L1 Straight Wire, #14 AWG, 1-3/8" Long
L2 1 Turn, #14 AWG, 3/8" ID, Length Plus Leads = 1"
RFC VK200-20/4B, FERROXCUBE.

OUTPUT POWER versus INPUT POWER

FIGURE 2 – 2N6082, 2N6083

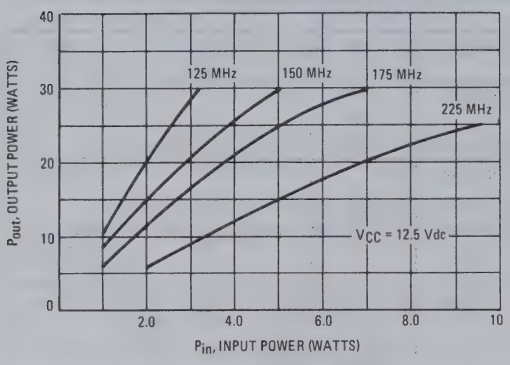
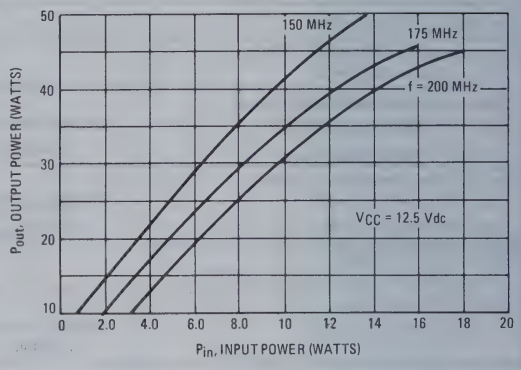


FIGURE 3 – 2N6084



OUTPUT POWER versus SUPPLY VOLTAGE

FIGURE 4 – 2N6082, 2N6083

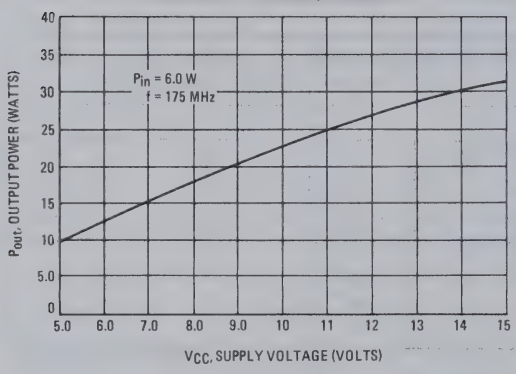
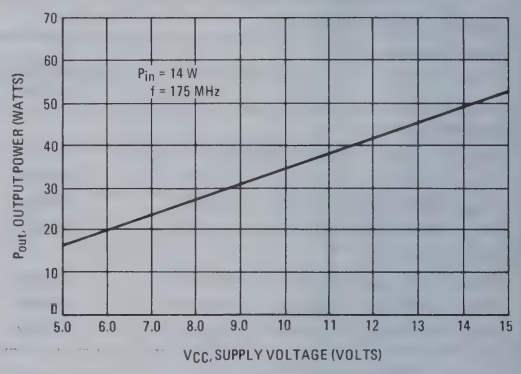


FIGURE 5 – 2N6084



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6 – 2N6082, 2N6083

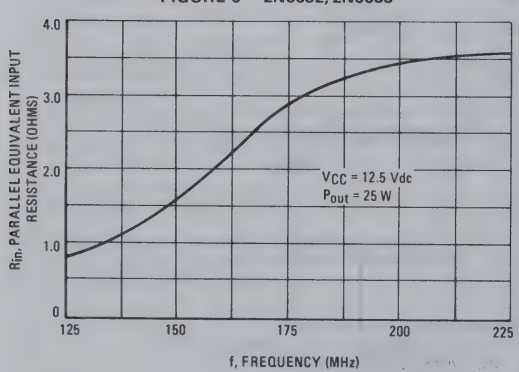
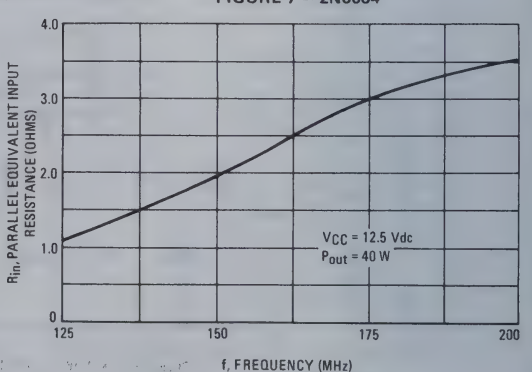


FIGURE 7 – 2N6084



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8 – 2N6082, 2N6083

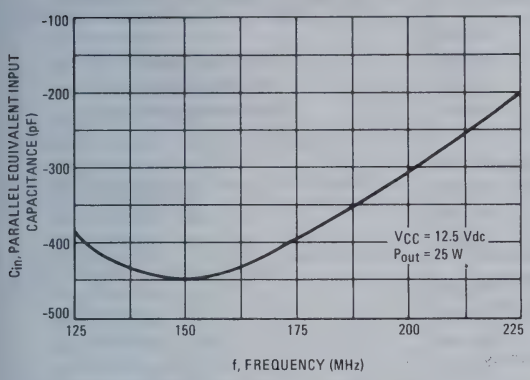
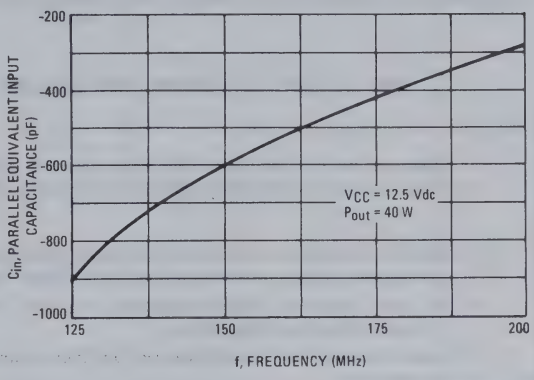


FIGURE 9 – 2N6084



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10 – 2N6082, 2N6083

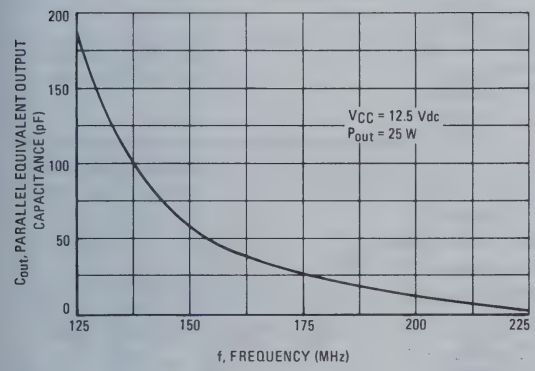
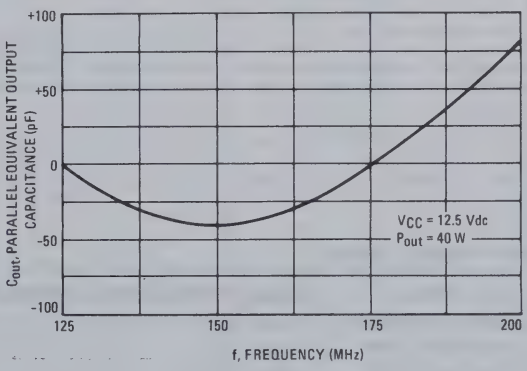


FIGURE 11 – 2N6084



TYPICAL 175 MHz AMPLIFIER BLOCK DIAGRAMS

FIGURE 12 – 160 WATTS OUTPUT

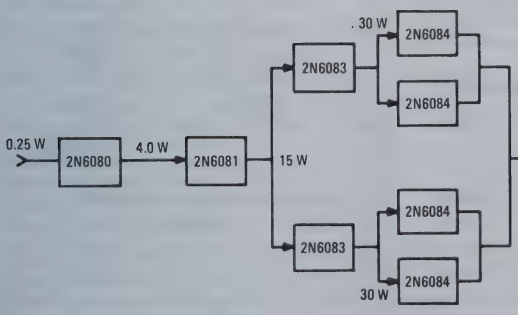
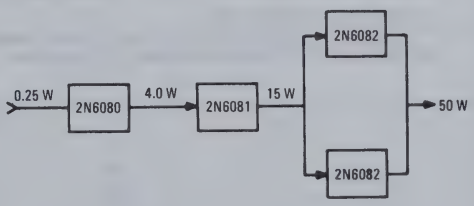


FIGURE 13 – 50 WATTS OUTPUT



2N6094 thru 2N6097 (SILICON)

The RF Line

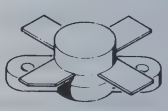
PNP SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt VHF large-signal amplifier applications required in military and industrial equipment operating to 250 MHz.

- Balanced Emitter Construction with Isothermal Resistor Design to Provide the Designer with the Optimum in Transistor Ruggedness
- Low Lead Inductance Stripline Packaging for Easier Design and Increased Broadband Capabilities
- Flange Package for Easy Mounting and Better Thermal Conductivity to Heat Sink
- Exceptional Power Output Stability versus Temperature

4.0, 15, 30, 40 WATTS - 175 MHz

PNP SILICON RF POWER TRANSISTORS

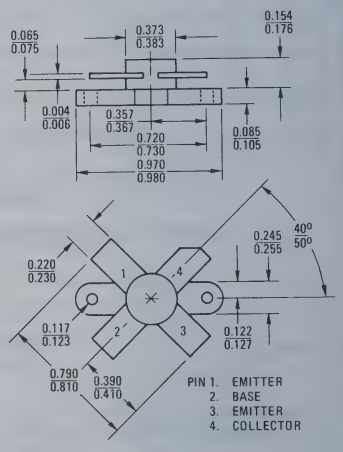


*MAXIMUM RATINGS

Rating	Symbol	2N6094	2N6095	2N6096	2N6097	Unit
Collector-Emitter Voltage	V_{CEO}	← 18 →				Vdc
Collector-Base Voltage	V_{CBO}	← 36 →				Vdc
Emitter-Base Voltage	V_{EBO}	← 4.0 →				Vdc
Collector Current — Continuous	I_C	1.0	2.5	4.0	6.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D(1)	8.0	20	40	60	Watts
Derate above 25°C		45.7	114	228	343	mW/°C
Storage Temperature Range	T_{stg}	← -65 to +200 →				°C

*Indicates JEDEC Registered Data.

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



To convert inches to millimeters multiply by 25.4

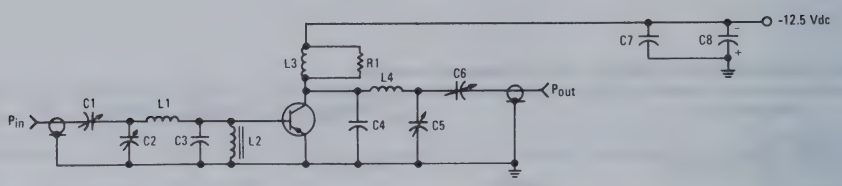
CASE 211-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	2N6094		18	–	–	
(I_C = 20 mAdc, I_B = 0)	2N6095		18	–	–	
(I_C = 50 mAdc, I_B = 0)	2N6096		18	–	–	
(I_C = 100 mAdc, I_B = 0)	2N6097		18	–	–	
Collector Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 5.0 mAdc, V_{BE} = 0)	2N6094		36	–	–	
(I_C = 10 mAdc, V_{BE} = 0)	2N6095		36	–	–	
(I_C = 15 mAdc, V_{BE} = 0)	2N6096		36	–	–	
(I_C = 20 mAdc, V_{BE} = 0)	2N6097		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N6094		4.0	–	–	
(I_E = 2.0 mAdc, I_C = 0)	2N6095		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	2N6096		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N6097		4.0	–	–	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	2N6094		–	–	5.0	
	2N6095		–	–	8.0	
	2N6096		–	–	10	
	2N6097		–	–	10	
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 15 Vdc, I_E = 0)	2N6094		–	–	250	μAdc
	2N6095		–	–	500	
	2N6096		–	–	1.0	mAdc
	2N6097		–	–	2.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 0.25 Adc, V_{CE} = 5.0 Vdc)	2N6094		5.0	–	–	
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	2N6095,2N6096,2N6097		15	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	2N6094		–	17	20	
	2N6095		–	90	120	
	2N6096		–	150	190	
	2N6097		–	300	400	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1)		G_{PE}				dB
(P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C(max) = 0.62 Adc, f = 175 MHz)	2N6094		12	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, I_C(max) = 1.9 Adc, f = 175 MHz)	2N6095		6.3	–	–	
(P_{out} = 30 W, V_{CC} = 12.5 Vdc, I_C(max) = 3.4 Adc, f = 175 MHz)	2N6096		5.7	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, I_C(max) = 4.3 Adc, f = 175 MHz)	2N6097		4.5	–	–	
Collector Efficiency (Figure 1)		η				%
(P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6094		50	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6095		55	–	–	
(P_{out} = 30 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6096		60	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	2N6097		60	–	–	

*Indicates JEDEC Registered Data

FIGURE 1 – 175 MHz TEST CIRCUIT



2N6094

C1,C2	ARCO 462 or Equivalent
C3,C4	7.0 pF Unelco J1HF
C5	ARCO 463 or Equivalent
C6	ARCO 461 or Equivalent
C7	1000 pF
C8	5.0 μF, 50 V
L1	25 nH, 1 Turn, #18 AWG, 1-1/4" Long, 1/4" I.D.
L2	VK200 20/4B Ferrite Choke, Ferroxcube
L3	150 nH, 8 Turns, #18 AWG, 3/4" Long, 3/16" I.D.
L4	36 nH, 1-1/2 Turns, #18 AWG, 1-1/4" Long, 1/4" I.D.
R1	390 Ohms, 1/2 W

2N6095

C1,C6	ARCO 462 or Equivalent
C2	ARCO 464 or Equivalent
C3,C4	40 pF Unelco J1HF
C5	ARCO 463 or Equivalent
C7	1000 pF
C8	5.0 μF, 50 V
L1	Copper Strap 1/4" Wide, 1-1/4" Long, Straight
L2	VK200 20/4B Ferrite Choke, Ferroxcube
L3	150 nH, 4 Turns, #18 AWG, 3/4" Long, Wound on R1
L4	1 Turn, #18 AWG, 1-1/4" Long, 1/4" I.D.
R1	390 Ohms, 1 W

2N6096

C1,C2	ARCO 462 or Equivalent
C3,C4	100 pF Unelco J1HF
C5,C6	ARCO 463 or Equivalent
C7	1000 pF
C8	5.0 μF, 50 V
L1	1/2 Turn, #16 AWG, 1-1/4" Long, 1/4" I.D.
L2	VK200 20/4B Ferrite Choke, Ferroxcube
L3	4 Turns, #18 AWG, 3/4" Long, Wound on R1
L4	1 Turn, #16 AWG, 1-1/4" Long, 1/4" I.D.
R1	390 Ohms, 2 W

2N6097

C1,C2,C5	ARCO 462 or Equivalent
C6	ARCO 464 or Equivalent
C3,C4	100 pF Unelco J1HF
C7	1000 pF
C8	5.0 μF, 50 V
L1	18 nH, 1-1/4" Straight, #16 AWG
L2	VK200 20/4B Ferrite Choke, Ferroxcube
L3	5 Turns, #18 AWG, 3/4" Long, Wound on R1
L4	1 Turn, #18 AWG, 1-1/4" Long, 1/4" I.D.
R1	160 Ohms, 2 W

OUTPUT POWER versus FREQUENCY

(V_{CC} = -12.5 Vdc)

FIGURE 2 – 2N6094

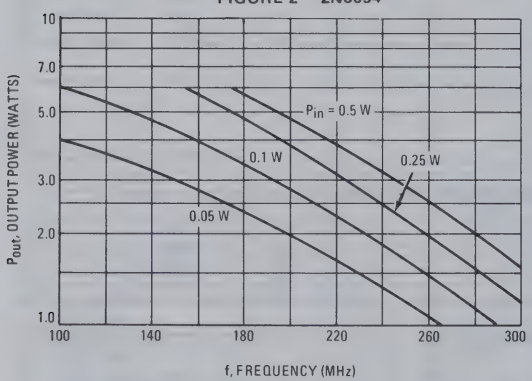


FIGURE 3 – 2N6095

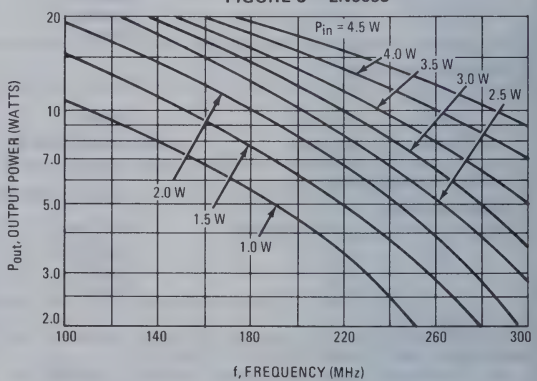


FIGURE 4 – 2N6096

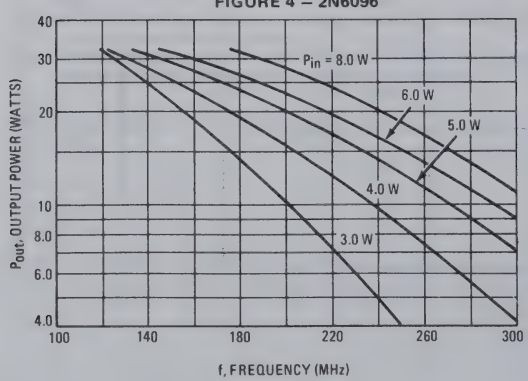
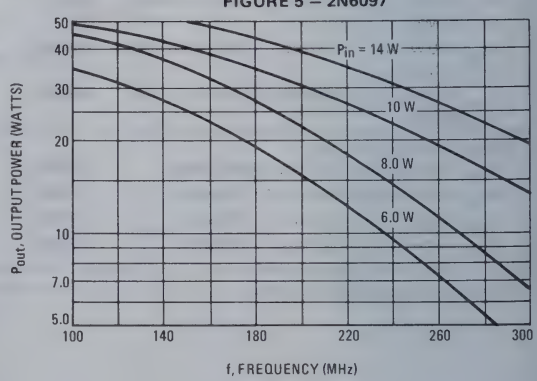


FIGURE 5 – 2N6097



TYPICAL PERFORMANCE DATA

OUTPUT POWER versus INPUT POWER

(V_{CC} = -12.5 Vdc, f = 175 MHz)

FIGURE 6 – 2N6094

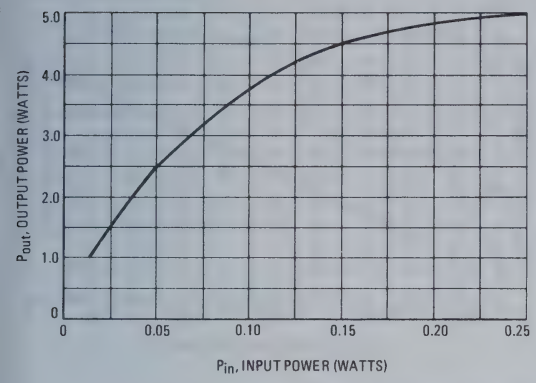


FIGURE 7 – 2N6095

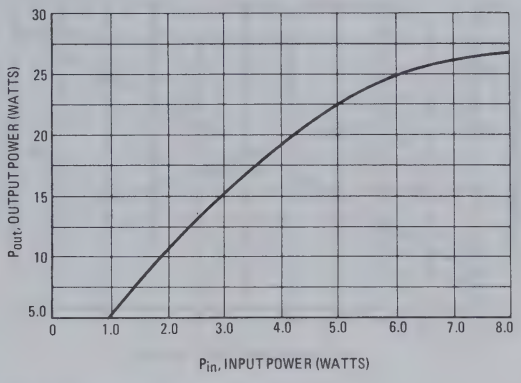


FIGURE 8 – 2N6096

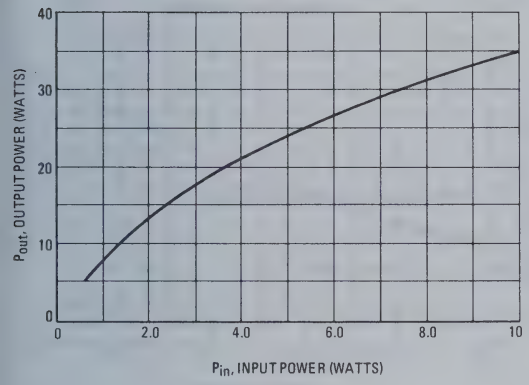
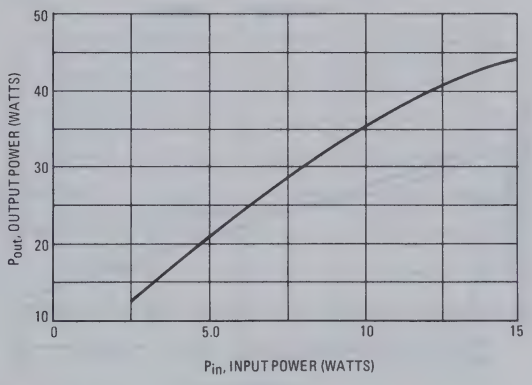


FIGURE 9 – 2N6097



CIRCUIT DESIGN DATA

OUTPUT POWER versus SUPPLY VOLTAGE

(f = 175 MHz)

FIGURE 10 – 2N6094

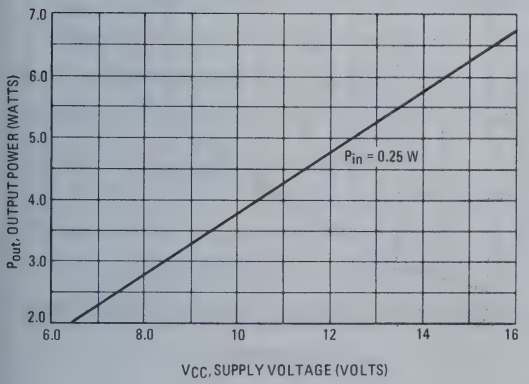
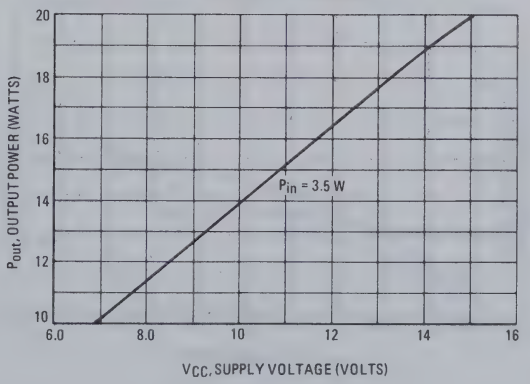


FIGURE 11 – 2N6095



CIRCUIT DESIGN DATA

OUTPUT POWER versus SUPPLY VOLTAGE

(f = 175 MHz)

FIGURE 12 – 2N6096

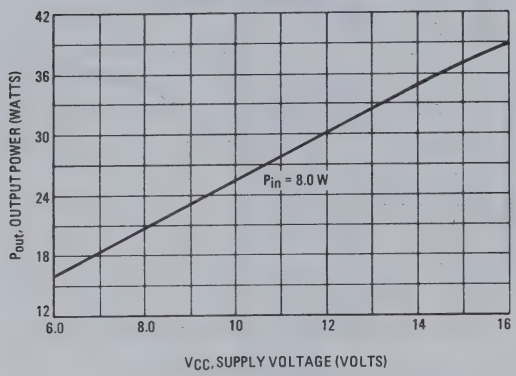
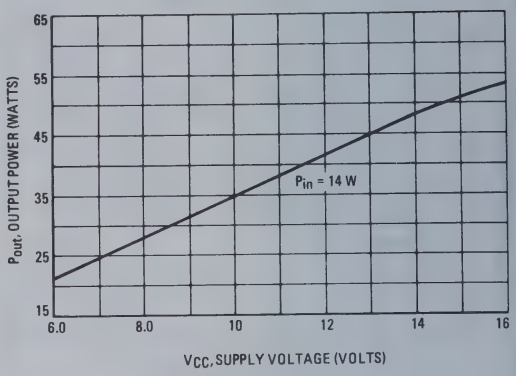


FIGURE 13 – 2N6097



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

(V_{CC} = -12.5 Vdc)

FIGURE 14 – 2N6094

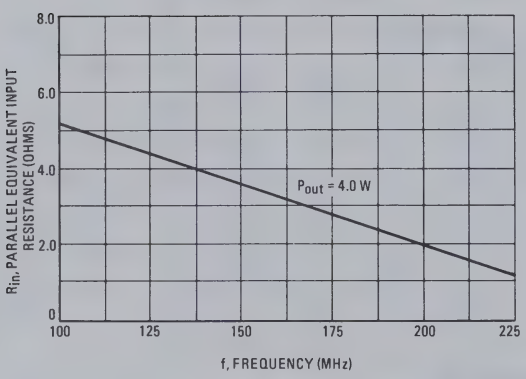


FIGURE 15 – 2N6095

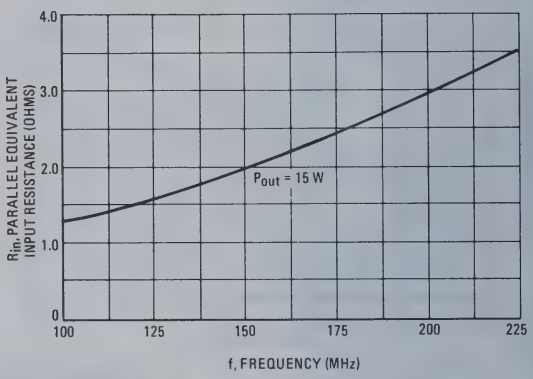


FIGURE 16 – 2N6096

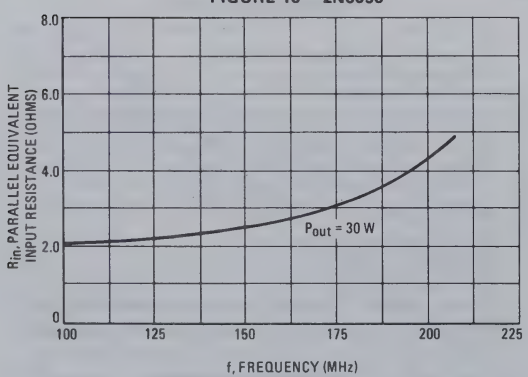
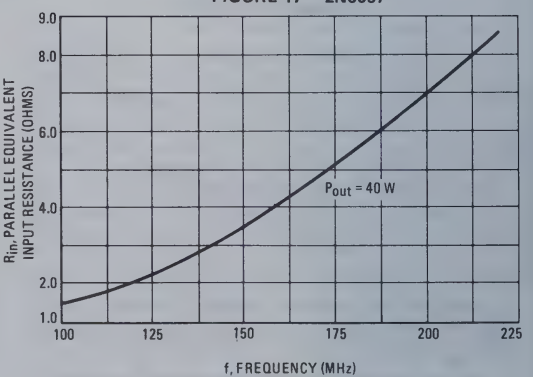


FIGURE 17 – 2N6097



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

(V_{CC} = -12.5 Vdc)

FIGURE 18 – 2N6094

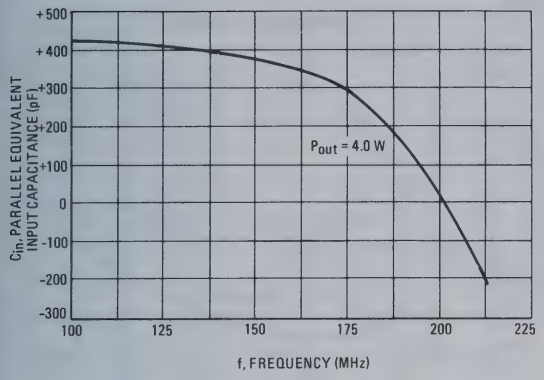


FIGURE 19 – 2N6095

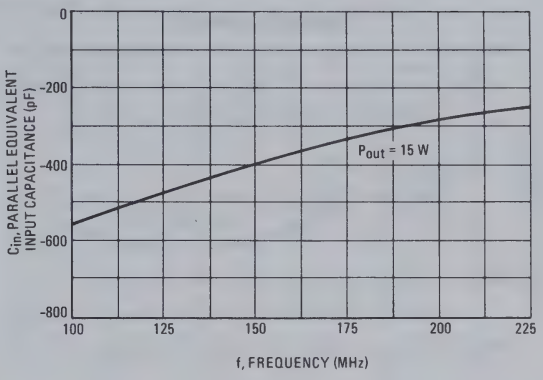


FIGURE 20 – 2N6096

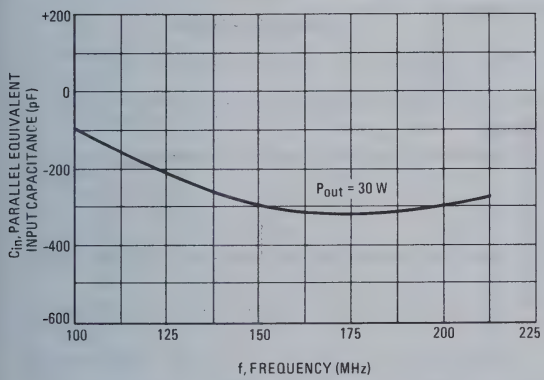
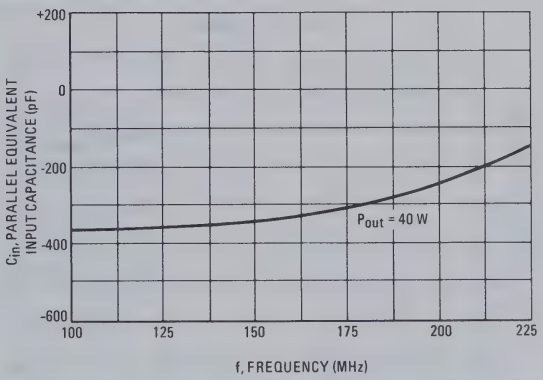


FIGURE 21 – 2N6097



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

(V_{CC} = -12.5 Vdc)

FIGURE 22 – 2N6094

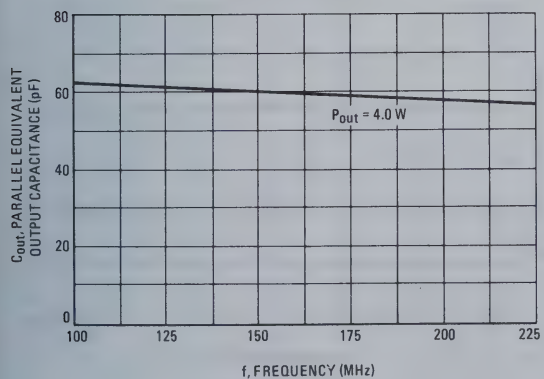
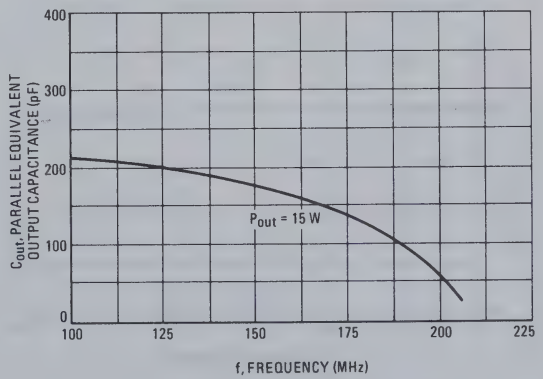


FIGURE 23 – 2N6095



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

(V_{CC} = -12.5 Vdc)

FIGURE 24 – 2N6096

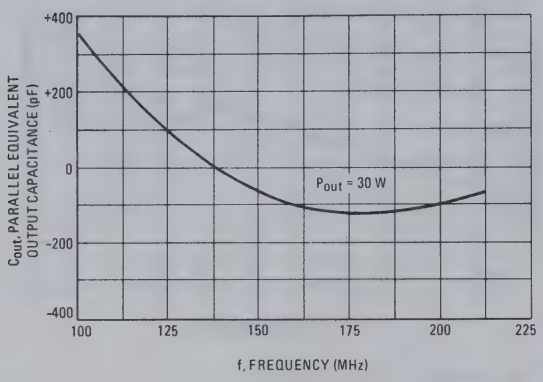
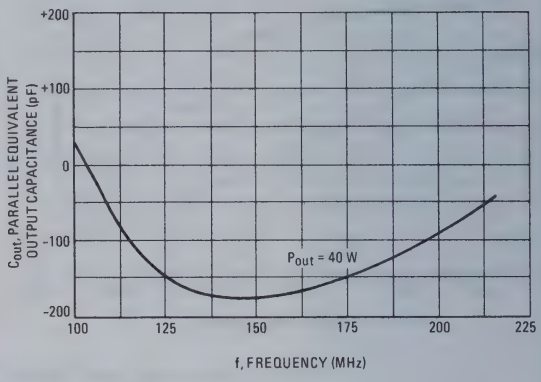


FIGURE 25 – 2N6097



TYPICAL OUTPUT POWER versus STUD TEMPERATURE

(V_{CC} = -12.5 Vdc, f = 175 MHz)

FIGURE 26 – 2N6094

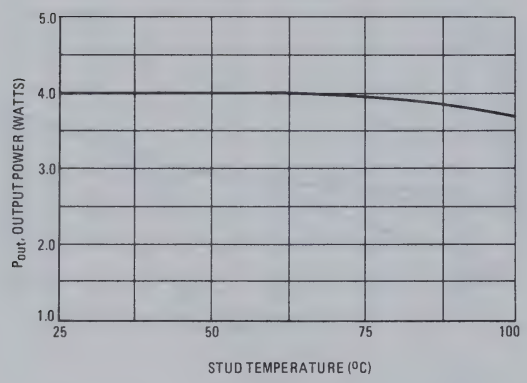


FIGURE 27 – 2N6095

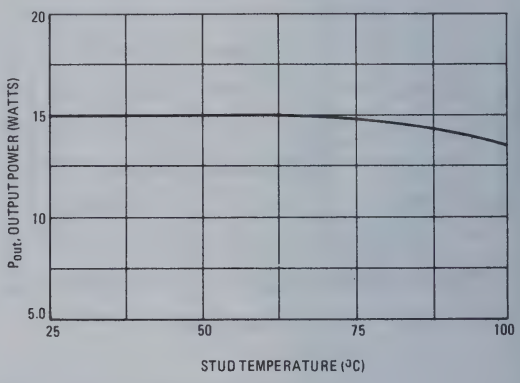


FIGURE 28 – 2N6096

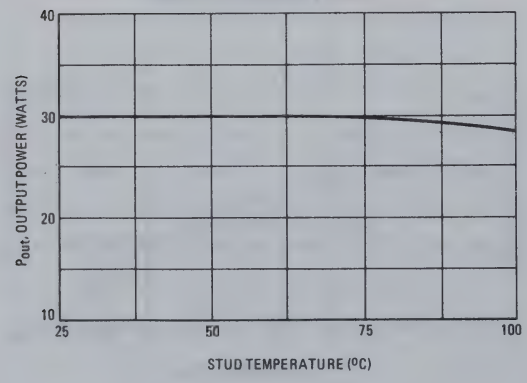


FIGURE 29 – 2N6097

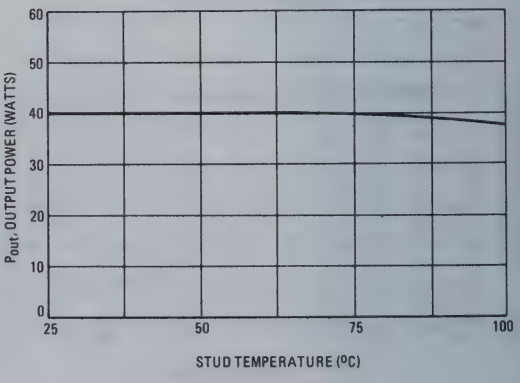
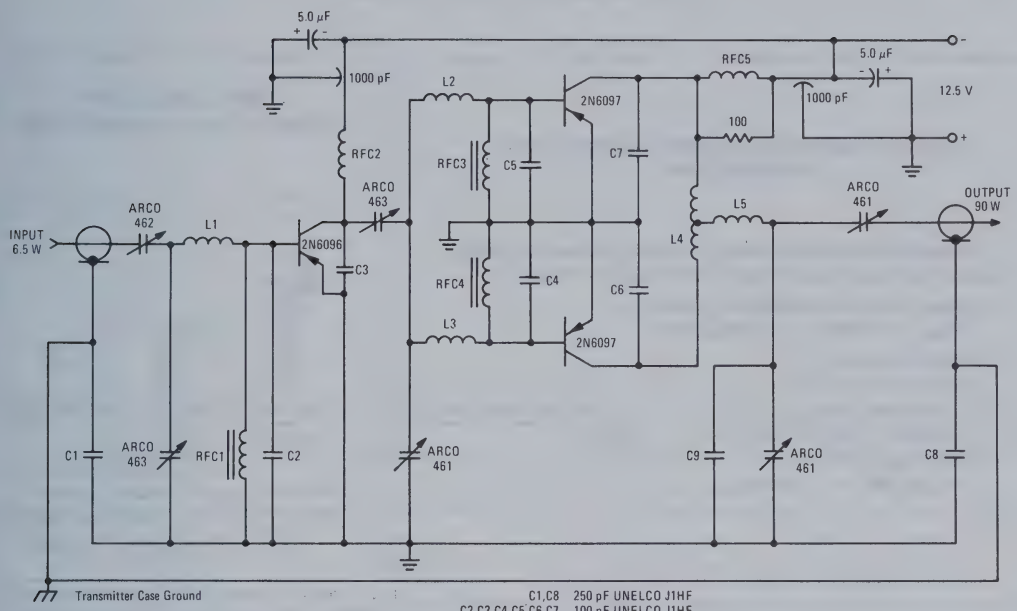


FIGURE 30 – 90-WATT, 175 MHz AMPLIFIER



C1,C8 250 pF UNELCO J1HF
C2,C3,C4,C5,C6,C7 100 pF UNELCO J1HF
C9 25 pF UNELCO J1HF
RFC1 VK200 – 20/4B Ferroxcube
RFC2 4 Turns, #18 AWG, L + Leads 1-1/2", 1/4" I.D.
RFC3, RFC4 0.15 μH Molded with Ferrite Bead on Ground Leg
RFC5 3 Turns, #16 AWG, on 2 W, 100 Ω Resistor
L1 1 Turn, #20 AWG, 1/4" I.D.
L2, L3 ST. PC., #18 AWG, 1-1/4" L
L4 1-1/4" x 1/4" x 0.03" Copper Strap Center Tapped
L5 1/2 Turn, #16 AWG, 1/4" I.D., 1/2" L

This is an example of a PNP amplifier designed for negative or positive ground operation. Floating the coaxial connectors with bypasses causes no gain loss. The chassis material is Printed Circuit Board which may easily be isolated from the transmitter cabinet.

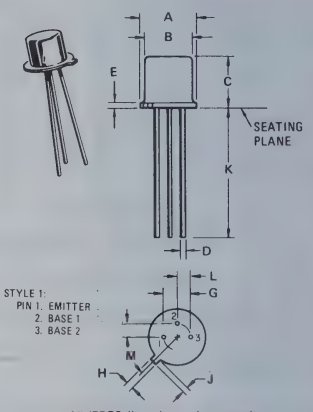
2N6114 (SILICON)
2N6115

SILICON COMPLEMENTARY UNIJUNCTION TRANSISTORS

. . . designed for oscillators, timers, frequency dividers and trigger circuits which require stability over wide temperature ranges.

- Interbase Resistance Temperature Coefficient –
  αR_{BB} = 0.05 (Min) to 0.5 (Max) %/°C
- Low Leakage Current –
  I_{EB2O} = 0.1 nA (Typ)
- Low Saturation Voltage –
  $V_{EB1(sat)}$ = 1.5 Vdc (Max)
- Instrinsic Standoff Ratio –
  η = 0.58 (Min) to 0.62 (Max)

COMPLEMENTARY UNIJUNCTION TRANSISTORS



All JEDEC dimensions and notes apply

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.310	5.840
B	0.178	0.195	4.520	4.950
C	0.170	0.210	4.320	5.330
D	0.016	0.019	0.406	0.483
E	–	0.030	–	0.762
G	0.100 NOM		2.540 NOM	
H	0.036	0.046	0.914	1.170
J	0.028	0.048	0.711	1.220
K	0.500	–	12.700	–
L	0.050 NOM		1.270 NOM	
M	45° NOM		45° NOM	

CASE 22A
TO-18

***MAXIMUM RATINGS** (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
DC Emitter Current	I_E	150	mA
Peak-Pulse Emitter Current Note 1	i_e	2.0	Amp
Emitter Reverse Voltage	V_{EB2O}	8.0	Volts
Interbase Voltage	V_{B2B1}	30	Volts
Power Dissipation Derate above T_A = 25°C	P_D	300 3.0	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-55 to +200	°C

*Indicates JEDEC Registered Data.
Note 1: Duty Cycle ≤ 1%, PRR = 10 PPS (See Figure 14).

FIGURE 1 – STANDARD UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

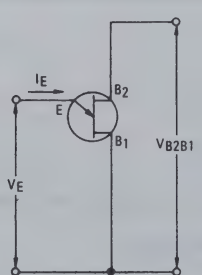


FIGURE 2 – COMPLEMENTARY UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

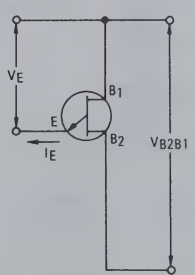
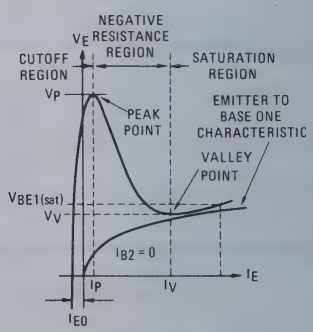


FIGURE 3 – STATIC EMITTER CHARACTERISTICS CURVES



***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Instrinsic Standoff Ratio (Note 2) ($V_{B2B1(1)}$ = 10 Vdc, $V_{B2B1(2)}$ = 5.0 Vdc)		η	0.58	–	0.62	–
Interbase Resistance (V_{B2B1} = 1.0 Vdc, I_E = 0)	2N6114 2N6115	R_{BB}	5.5 5.0	6.8 8.0	8.2 15	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 1.0 Vdc, I_E = 0, T_A = -55 to +100°C)		αR_{BB}	0.05	–	0.5	%/°C
Emitter Saturation Voltage (Note 3) (V_{B2B1} = 10 Vdc, I_E = 50 mA)		$V_{EB1(sat)}$	–	1.1	1.5	Volts
Modulated Interbase Current (V_{B2B1} = 10 Vdc, I_E = 50 mA)		$I_{B2(mod)}$	1.0	4.0	10	mA
Emitter Reverse Current (V_{EB2} = 5.0 Vdc, I_{B1} = 0)	2N6114 2N6115	I_{EB2O}	– –	0.1 0.1	100 10	nA
Peak-Point Emitter Current (V_{B2B1} = 10 Vdc)	2N6114 2N6115	I_P	– –	– –	5.0 15	μA
Valley-Point Emitter Current (Note 3) (V_{B2B1} = 10 Vdc)		I_V	1.0	4.5	–	mA
Peak-Point Voltage (V_{B2B1} = 5.0 Vdc) (V_{B2B1} = 10 Vdc)		V_P	3.2 6.1	3.45 6.45	3.7 6.8	Volts
Base-One Peak Pulse Voltage (Figure 15)		V_{OB1}	3.5	4.5	–	Volts
Emitter Breakdown Voltage (I_{EB1} = 10 μA)		V_{EBIO}	8.0	9.5	–	Volts
Diode Voltage (Note 2)		V_D	0.3	–	0.6	Volts
Minimum Charge to Trigger		Q_t	–	50	–	PC
Turn On Time		t_{on}	–	0.85	–	μs
Recovery Time		t_{rec}	–	7.0	–	μs

*Indicates JEDEC Registered Data.

Note 2: Intrinsic Standoff Ratio (η) is defined in terms of the Peak-Point Voltage (Vp) by means of the equation:

$$\eta = \frac{V_{P1} - V_{P2}}{V_{B2B1(1)} - V_{B2B1(2)}}$$ where $V_{B2B1(1)}$ = 10 Vdc ± 0.001 Vdc and $V_{B2B1(2)}$ = 5.0 Vdc. The associated Diode Voltage (V_D) is defined by the equation $V_D = V_{P2} - \eta V_{B2B1(2)}$.

Note 3: Use pulse techniques: PW ≈ 300 μs, duty cycle ≤ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 4 – STATIC EMITTER CHARACTERISTICS

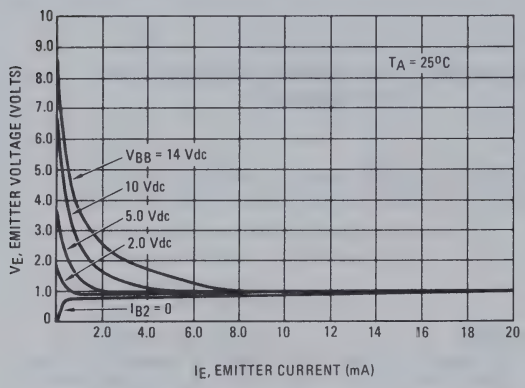
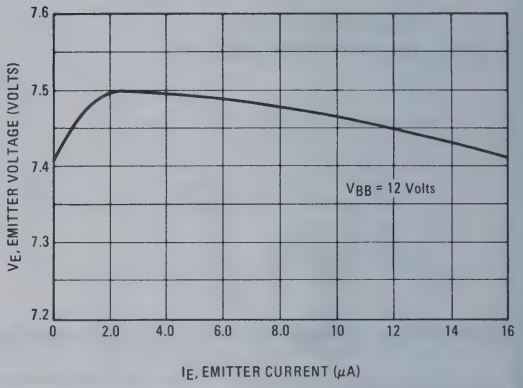


FIGURE 5 – PEAK POINT CHARACTERISTICS



PEAK POINT CURRENT

FIGURE 6 – EFFECT OF VOLTAGE

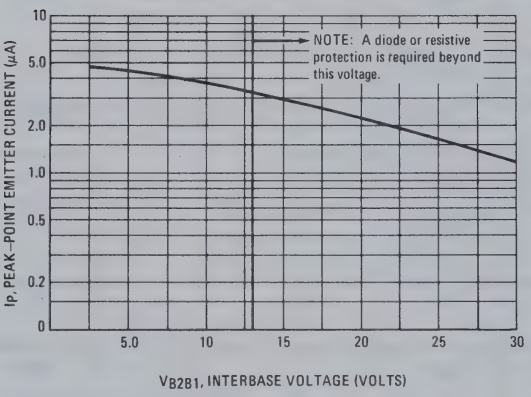
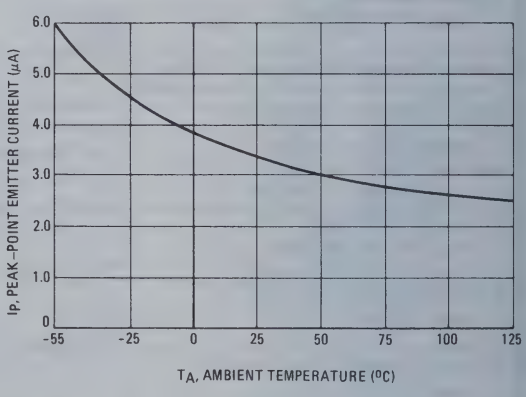


FIGURE 7 – EFFECT OF TEMPERATURE



VALLEY CURRENT

FIGURE 8 – EFFECT OF VOLTAGE

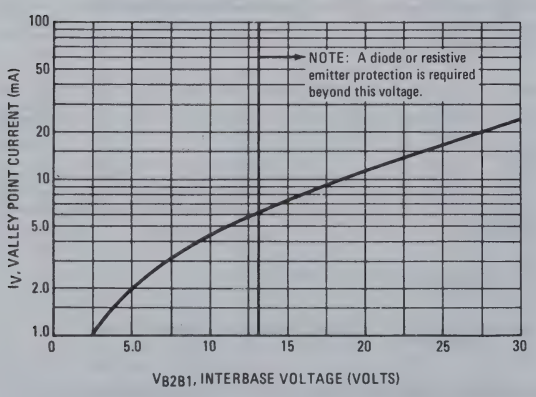


FIGURE 9 – EFFECT OF TEMPERATURE

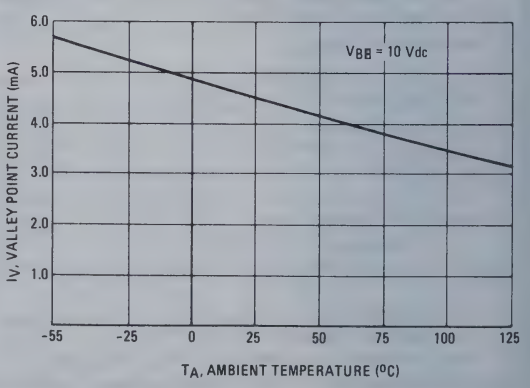


FIGURE 10 – DIODE VOLTAGE

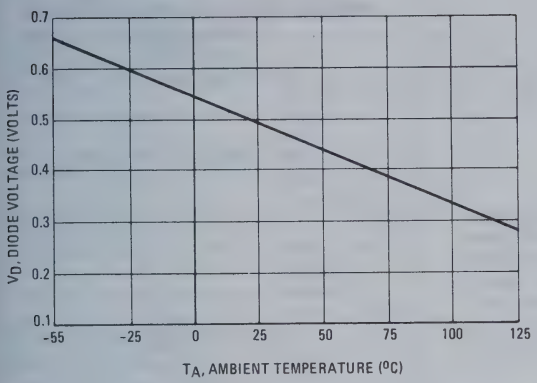


FIGURE 11 – EMITTER LEAKAGE CURRENT

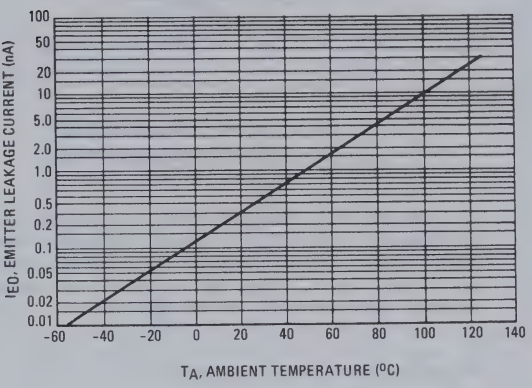


FIGURE 12 – STATIC INTERBASE CHARACTERISITCS

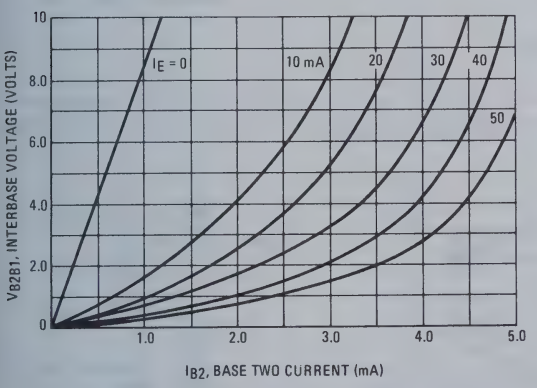


FIGURE 13 – INTERBASE RESISTANCE

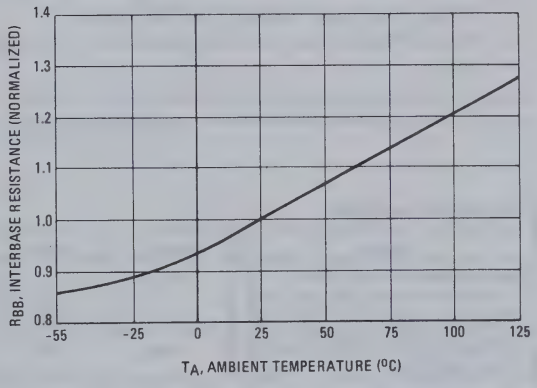


FIGURE 14 – PEAK EMITTER CURRENT TEST CIRCUIT AND WAVEFORM

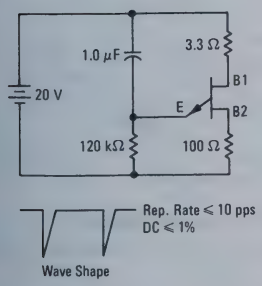


FIGURE 15 – BASE-ONE PEAK PULSE VOLTAGE CIRCUIT

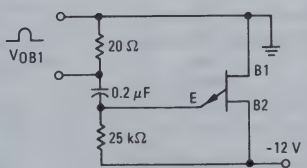
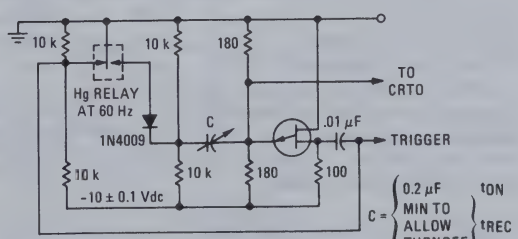


FIGURE 16 – SWITCHING CIRCUIT



2N6116 (SILICON)
2N6117
2N6118



SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS
40 VOLTS
250 mW

SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-triggor, oscillator, pulse and timing circuits. These devices may also be used in special thyristor applications due to the availability of an anode gate.

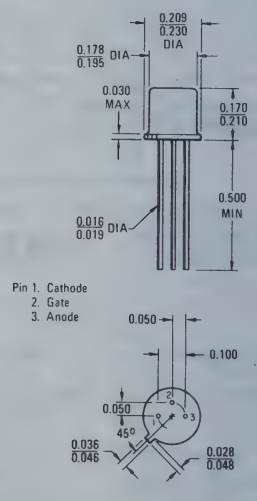
- Programmable – R_{BB}, η, I_V and I_P
- Hermetic TO-18 Package
- Low On-State Voltage – 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current – 5.0 nA Maximum
- High Peak Output Voltage – 16 Volts Typical
- Low Offset Voltage – 0.35 Volt Typical (R_G = 10 k ohms)



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
DC Forward Anode Current Derate Above 25°C	I_T	200 2.0	mA mA/°C
DC Gate Current	I_G	±20	mA
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt
Forward Power Dissipation @ T_A = 25°C Derate Above 25°C	P_F $1/\theta_{JA}$	250 2.5	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data



CASE 22-03
TO-18

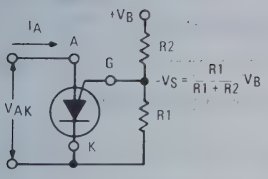
All JEDEC dimensions and notes apply

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

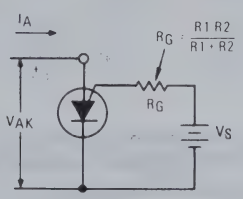
Characteristic		Figure	Symbol	Min	Typ	Max	Unit
Offset Voltage	2N6116	1	V_T	0.2	0.70	1.6	Volts
(V_S = 10 Vdc, R_G = 1.0 MΩ)	2N6117			0.2	0.50	0.6	
	2N6118			0.2	0.40	0.6	
(V_S = 10 Vdc, R_G = 10 k ohms)	All Types			0.2	0.35	0.6	
Gate to Anode Leakage Current		–	I_{GAO}				nAdc
(V_S = 40 Vdc, T_A = 25°C, Cathode Open)				–	1.0	5.0	
(V_S = 40 Vdc, T_A = 75°C, Cathode Open)				–	30	75	
Gate to Cathode Leakage Current		–	I_{GKS}	–	5.0	50	nAdc
(V_S = 40 Vdc, Anode to Cathode Shorted)							
Peak Current	2N6116	2,9-14	I_p	–	1.25	2.0	μA
(V_S = 10 Vdc, R_G = 10 MΩ)	2N6117			–	0.19	0.3	
	2N6118			–	0.08	0.15	
(V_S = 10 Vdc, R_G = 10 k ohms)	2N6116			–	4.0	5.0	
	2N6117			–	1.20	2.0	
	2N6118			–	0.70	1.0	
Valley Current		1,4,5	I_V				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	2N6116, 2N6117			–	18	50	
	2N6118			–	18	25	
(V_S = 10 Vdc, R_G = 10 k ohms)	2N6116			70	270	–	
	2N6117, 2N6118			50	270	–	
Forward Voltage (I_F = 50 mA Peak)		1,6	V_T	–	0.8	1.5	Volts
Peak Output Voltage		3,7	V_o	6.0	16	–	Volts
(V_B = 20 Vdc, C_C = 0.2 μF)							
Pulse Voltage Rise Time		3	t_r	–	40	80	ns
(V_B = 20 Vdc, C_C = 0.2 μF)							

*Indicates JEDEC Registered Data

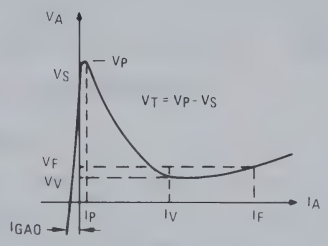
FIGURE 1 – ELECTRICAL CHARACTERIZATION



1A – PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2



1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)



1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (I_p) TEST CIRCUIT

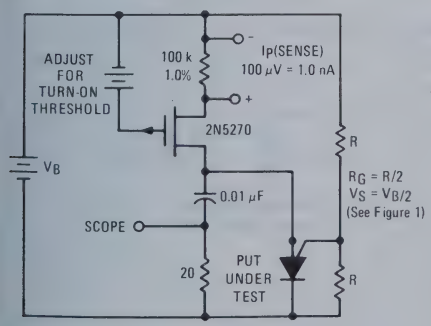
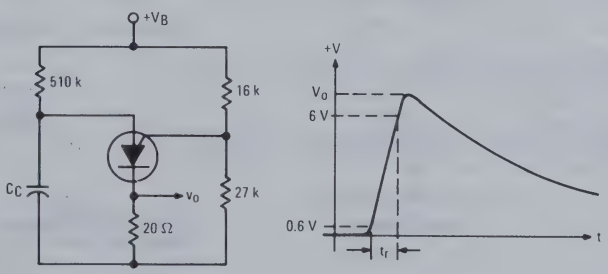


FIGURE 3 – V_o AND t_r TEST CIRCUIT



TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

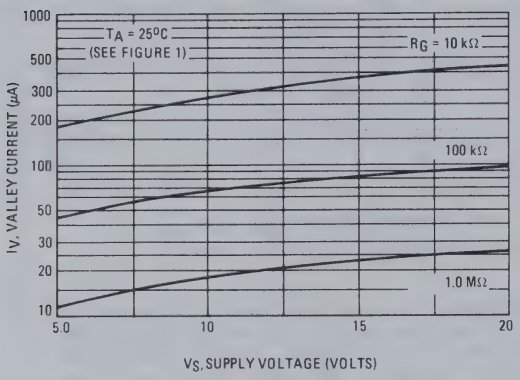


FIGURE 5 – EFFECT OF TEMPERATURE

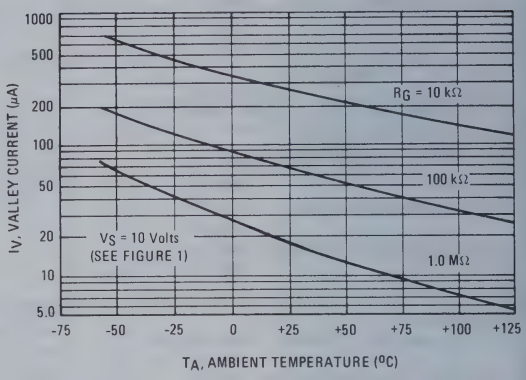


FIGURE 6 – FORWARD VOLTAGE

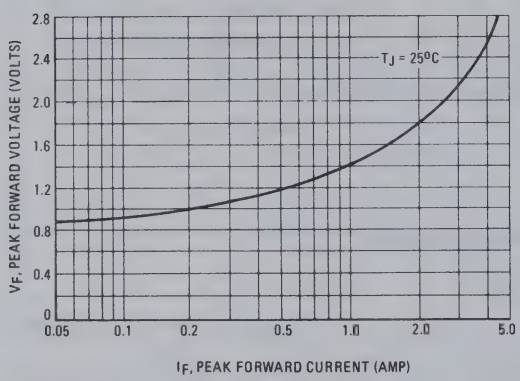


FIGURE 7 – PEAK OUTPUT VOLTAGE

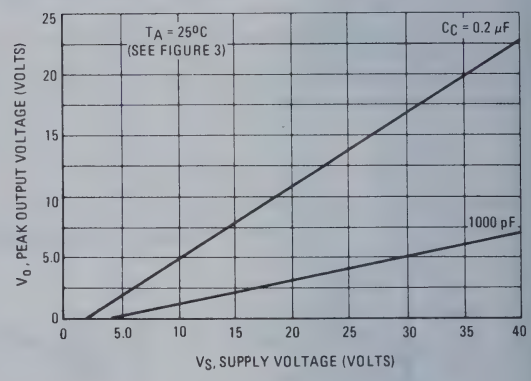
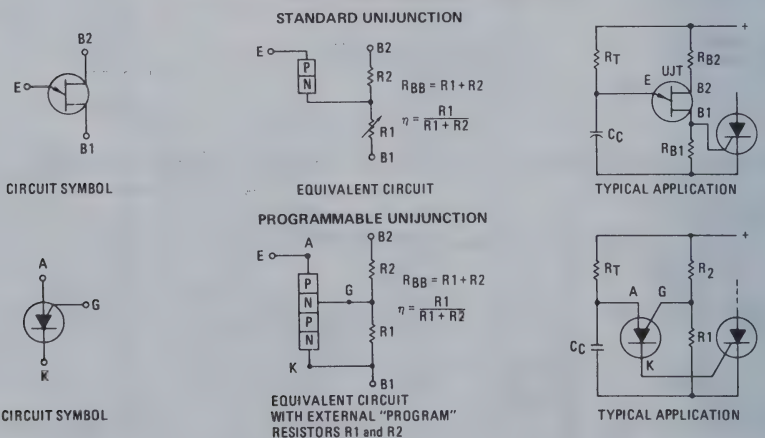


FIGURE 8 – STANDARD UNIJUNCTION COMPARED TO PROGRAMMABLE UNIJUNCTION



TYPICAL PEAK CURRENT BEHAVIOR

2N6116

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

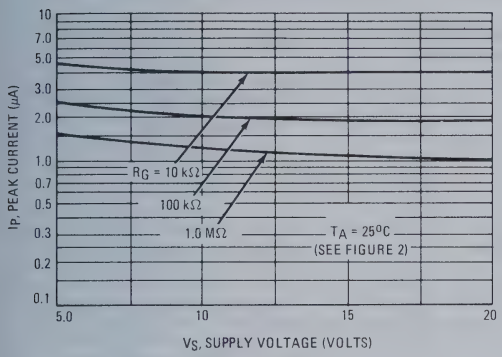
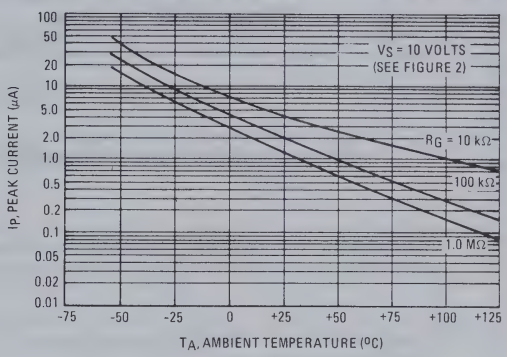


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



2N6117

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

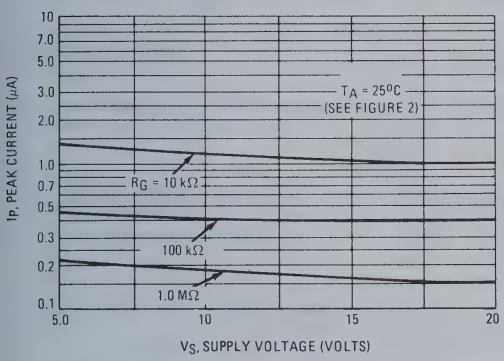
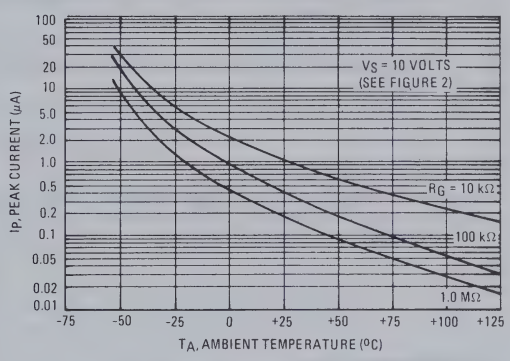


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



2N6118

FIGURE 13 – EFFECT OF SUPPLY VOLTAGE AND R_G

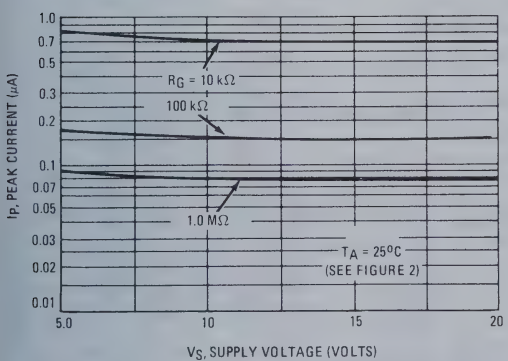
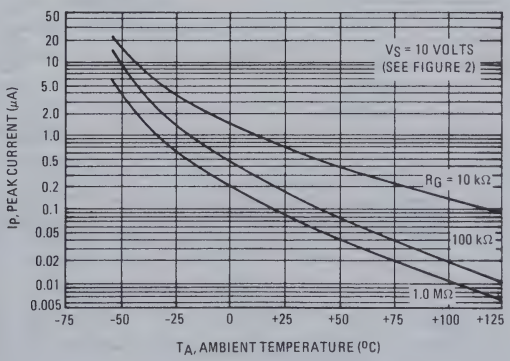


FIGURE 14 – EFFECT OF TEMPERATURE AND R_G



2N6136 (SILICON)

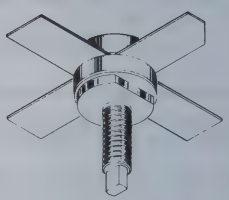
The RF Line

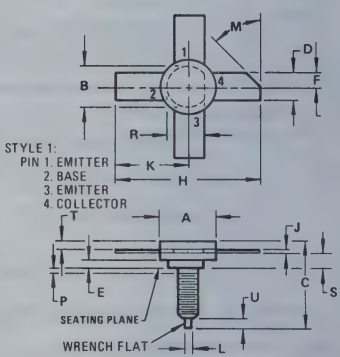
NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 520 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 25 Watts
  Minimum Gain = 4.0 dB
  Efficiency = 65%
- Overlay Construction Provides Protection Against Device Damage Due to Load Mismatch
- Characterized With Series Equivalent Large-Signal Impedance Parameters

25 W – 470 MHz
RF POWER
TRANSISTOR
NPN SILICON





***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	6.0	Adc
Total Device Dissipation @ T_C = 25°C (2) Derate above 25°C	P_D	60 0.343	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (1)	–	6.5	in. lb.

*Indicates JEDEC Registered Data
(1) For repeated assembly use 5 in. lb.
(2) This device is designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

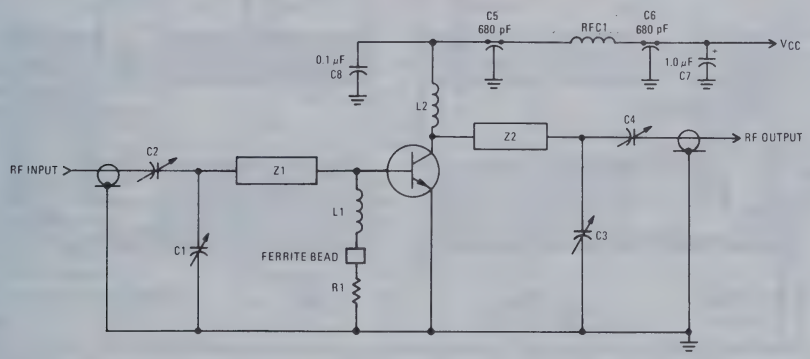
CASE 145A-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	55	70	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	G_{PE}	4.0	–	–	dB
Collector Efficiency (P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	η	65	–	–	%

*Indicates JEDEC Registered Data

FIGURE 1 – 470 MHz TEST CIRCUIT SCHEMATIC



Note: Test circuit layout shown in Figure 6.

FIGURE 2 – OUTPUT POWER versus INPUT POWER

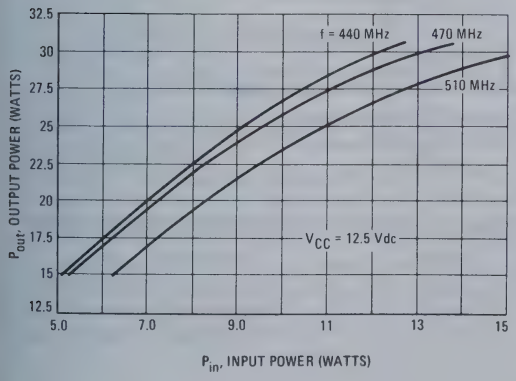


FIGURE 3 – OUTPUT POWER versus FREQUENCY

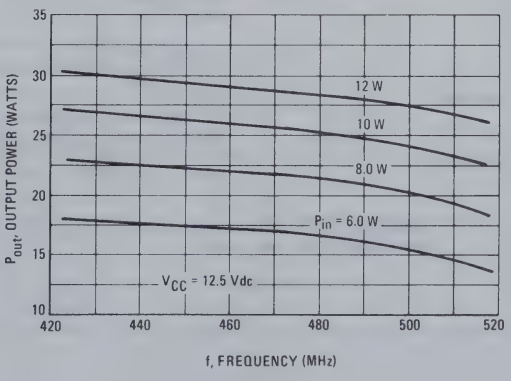


FIGURE 4 –
OUTPUT POWER versus SUPPLY VOLTAGE

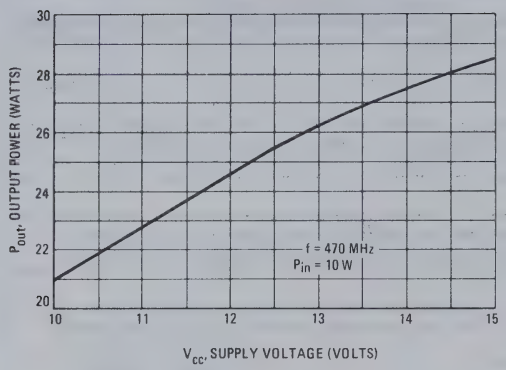


FIGURE 5 –
SERIES EQUIVALENT IMPEDANCE PARAMETERS

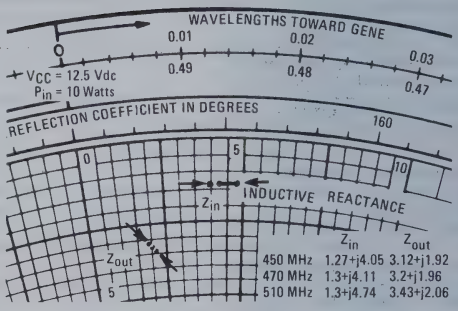
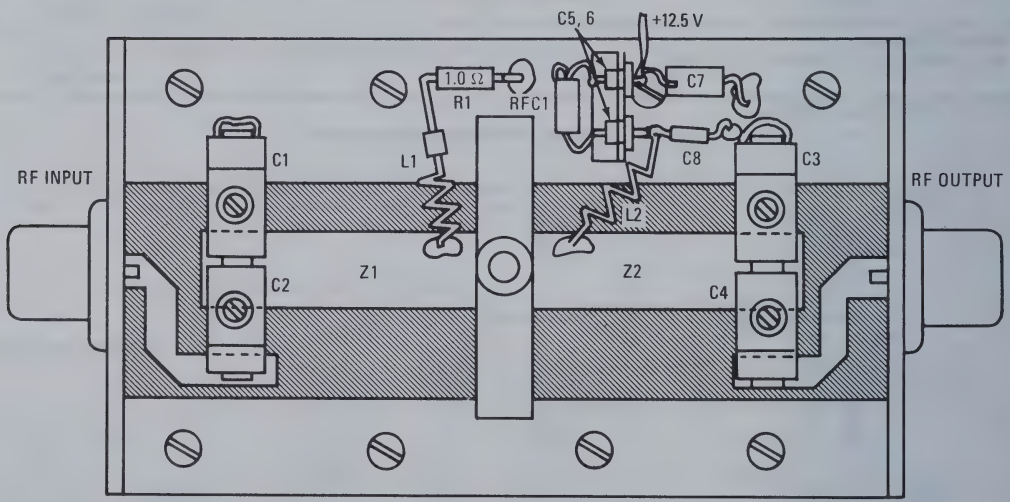


FIGURE 6 –
470 MHz TEST CIRCUIT LAYOUT
(1:1 Scaled Drawing)



C1, 2, 3, 4 — 1.0-25pF ARCO 421 OR EQUIVALENT UHF COMPRESSION MICAS

L1, L2 — 5 Turns #20 AWG 0.2 I.D. FERRITE BEAD, FERROXCUBE 56-590-65-3B AS SHOWN ON L1

C5,6 – 680 pF FT. CAPACITOR
C7 – 1.0 μF, 35V TANTALUM CAPACITOR
RFC1 – CHOKE FERROXCUBE VK 200-20-4B
C8 – 0.1 μF ERIE CK06

R1 1.0 OHM, 1/2 WATT

CONNECTORS ARE TYPE "N"
BOARD IS GLASS TEFLON
3" X 5" X 0.062" 1 oz COPPER BOTH SIDES
SHOWN TO SCALE
CLADDING REMOVED IN DARK AREAS
MOUNTING PLATE IS 3" X 5" X 0.75" ALUMINUM

Z1 and Z2 BASE AND COLLECTOR LINES ARE 0.5" X 1.75"

Note: Figure 6 is 1:1 scaled layout of test circuit shown in Figure 1. This layout may be transferred directly to glass teflon board for easy reproduction of the test circuit.

2N6139 thru 2N6144 (SILICON)
2N6148 thru 2N6150



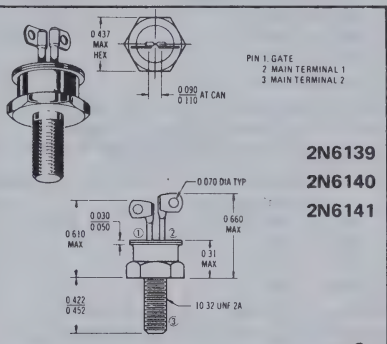
SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 100 Amp
- Low Forward "On" Voltage — 1.4 V typ @ I_{TM} = 14 A
- All Diffused and Passivated Junctions for Greater Stability
- Rugged Construction in Either 3 Lead, Stud or Isolated Stud Package
- Gate Triggering Guaranteed in Four Modes

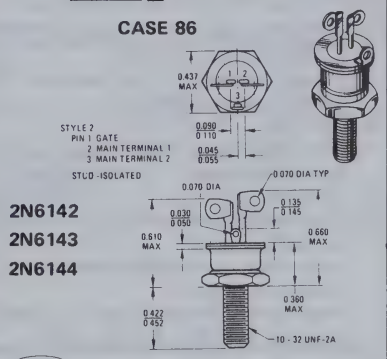
TRIACS (THYRISTORS)

10 AMPERES RMS



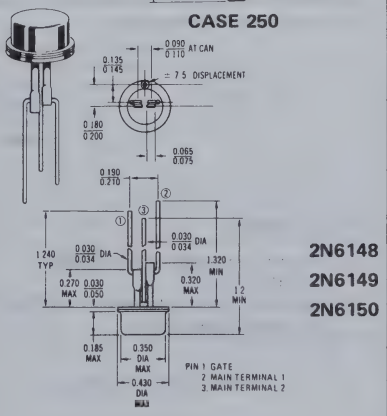
2N6139
2N6140
2N6141

CASE 86



2N6142
2N6143
2N6144

CASE 250



2N6148
2N6149
2N6150

CASE 87L

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage, Note 1 (T_J = -65 to +100°C, ½ Sine Wave 50 to 60 Hz, Gate Open)	V_{DRM}		Volts
*Peak Principle Voltage 2N6139, 2N6142, 2N6148 2N6140, 2N6143, 2N6149 2N6141, 2N6144, 2N6150		 200 400 600	
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (-65 to +75°C) (Full Cycle Sine Wave, 50 to 60 Hz) (+90°C)	$I_{T(RMS)}$	10 5.0	Amp
*Peak Surge Current (One Full Cycle, 60 Hz, T_J = +75°C, preceded and followed by 10 A current)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -65 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power (T_J = +75°C, Pulse Width = 2.0 μ)	P_{GM}	20	Watts
*Average Gate Power (T_J = +75°C, t = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-65 to +100	°C
*Storage Temperature Range	T_{stg}	-65 to +150	°C
*Stud Torque 2N6139 thru 2N6144	—	15	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R\theta_{JC}$	2.0	°C/W
Thermal Resistance, Case to Ambient	$R\theta_{CA}$	50	°C/W

*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
*On-State Voltage (Either Direction) I_{TM} = 14 A Peak, Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤2.0 %	V_{TM}	–	1.4	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms, Minimum Gate Pulse Width = 2.0 μs	I_{GT}				mA
MT2 (+), G(+)		–	6.0	50	
MT2 (+), G(–)		–	6.0	75	
MT2 (–), G(–)		–	10	50	
MT2 (–), G(+)		–	25	75	
*MT2 (+), G(+); MT2 (–), G(–) T_C = –65°C		–	–	125	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –65°C		–	–	150	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms, Minimum Gate Pulse Width = 2.0 μs	V_{GT}				Volts
MT2 (+), G(+)		–	0.9	2.0	
MT2 (+), G(–)		–	0.9	2.5	
MT2 (–), G(–)		–	1.1	2.0	
MT2 (–), G(+)		–	1.4	2.5	
*MT2 (+), G(+); MT2 (–), G(–) T_C = –65°C		–	–	2.5	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –65°C		–	–	3.0	
*Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 100°C		0.2	–	–	
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 300 mA; T_C = 25°C	I_H	–	6.0	40	mA
T_C = –65°C		–	–	150*	
*Turn-On Time Main Terminal Voltage = Rated V_{DRM}, I_{TM} = 14 A, Gate Source Voltage = 12 V, R_S = 50 Ohms, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	tgt	–	1.5	2.0	μs
Blocking Voltage Application Rate at Commutation, f=60 Hz, T_C=75°C On-State Conditions: I_{TM} = 14 A, Pulse Width = 4.0 ms, di/dt=5.3 A/ms Off-State Conditions: Main Terminal Voltage = Rated V_{DRM} (200 μs min), Gate Source Voltage = 0 V, R_S = 100 Ω	dv/dt	–	5.0	–	V/μs

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

Trigger devices are recommended for gating on Triacs.

Triggers Provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

Electrical Characteristics	For General Usage		For Lamp Dimmer
Symbol	MBS4991	MBS4992	MBS100
V_S =	6.0 –10 V	7.5–9.0 V	3.0–5.0 V
I_S =	350 μA Max	120 μA Max	100–400 μA
V_{S1}–V_{S2} =	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient = 0.02%/°C Typ			

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

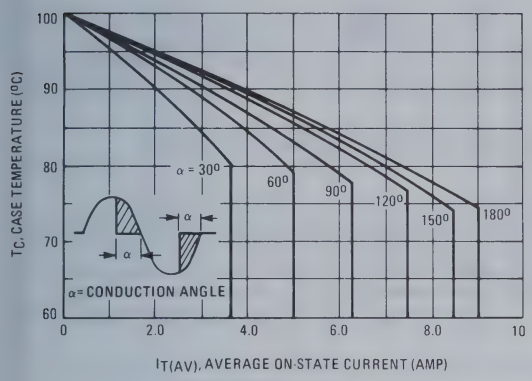


FIGURE 2 – RMS CURRENT DERATING

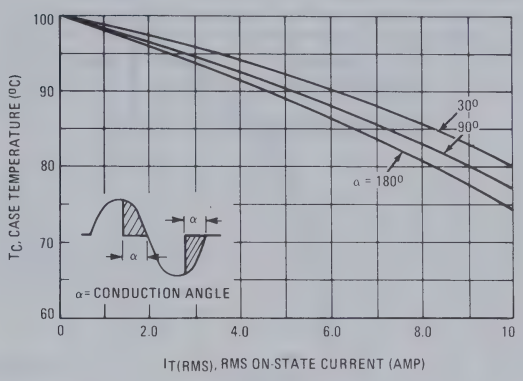


FIGURE 3 – POWER DISSIPATION

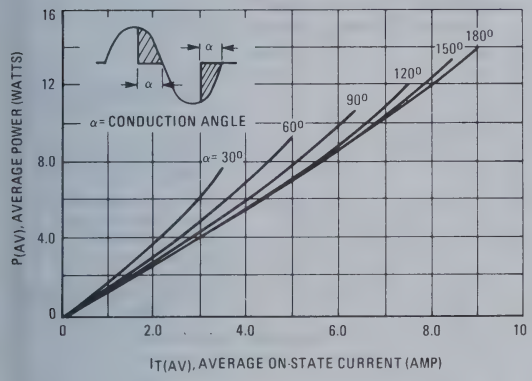


FIGURE 4 – POWER DISSIPATION

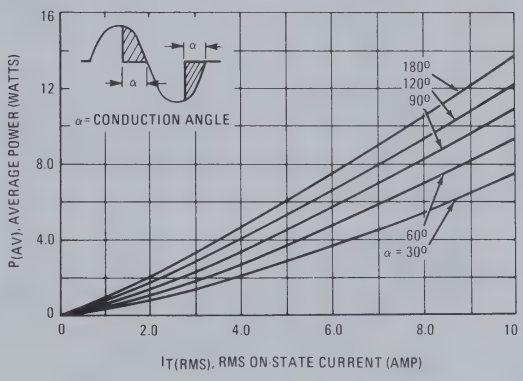


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

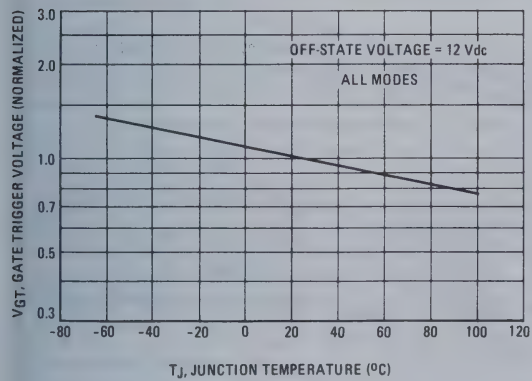


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

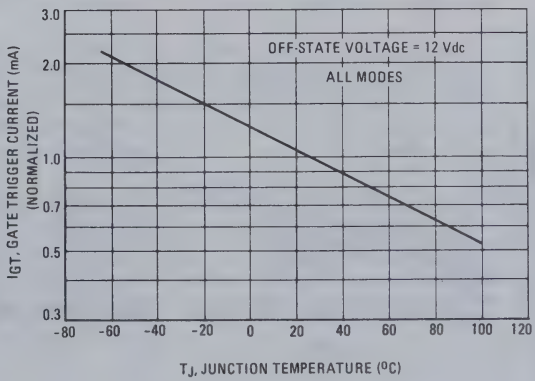


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

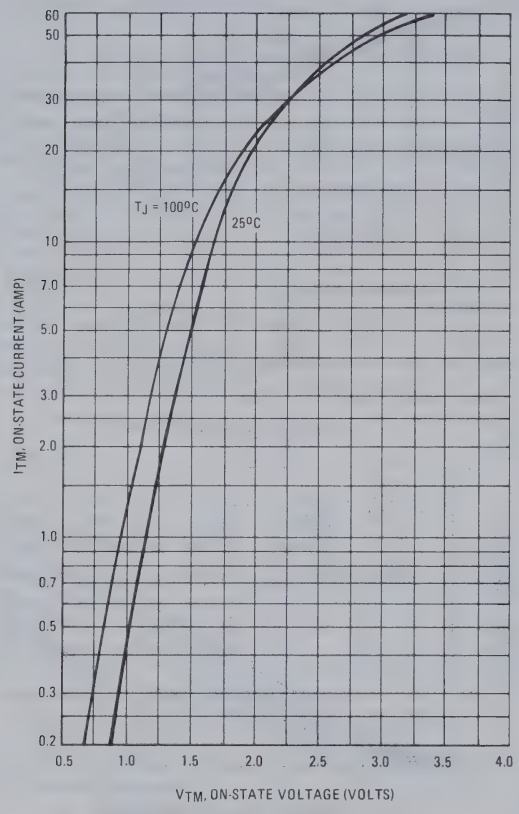


FIGURE 8 – TYPICAL HOLDING CURRENT

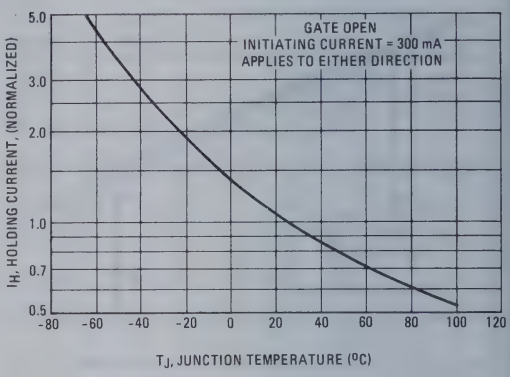


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

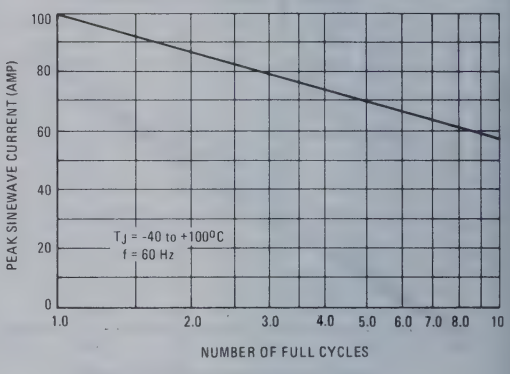
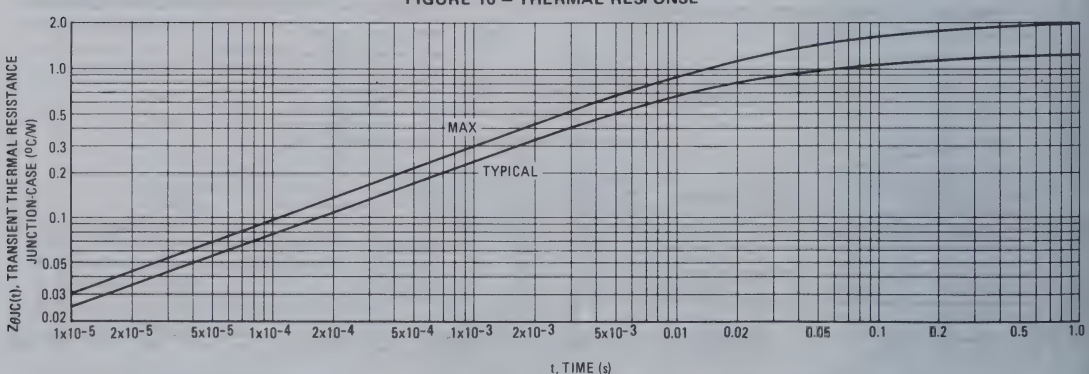


FIGURE 10 – THERMAL RESPONSE



2N6145 thru 2N6147 (SILICON)

For Specifications, See 2N5571 Data.

2N6151 (SILICON) thru 2N6156



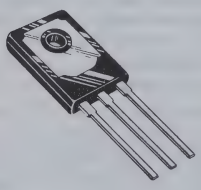
SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- All Diffused and Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Gate Triggering Guaranteed in Two (2N6154, 2N6155, 2N6156) or Four Modes (2N6151, 2N6152, 2N6153)

TRIACS (THYRISTORS)

10 AMPERES RMS



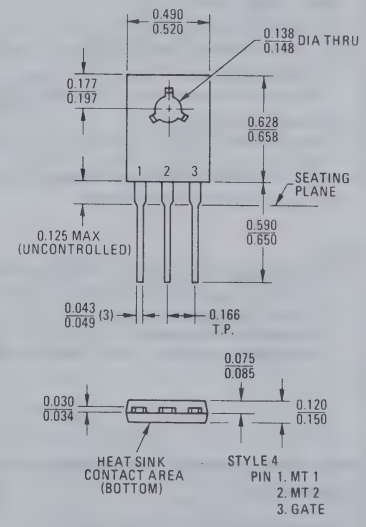
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
* Repetitive Peak Off-State Voltage, Note 1 (T_J = -40 to +100°C) ½ Sine Wave 50 to 60 Hz, Gate Open Peak Principle Voltage 2N6151, 2N6154 2N6152, 2N6155 2N6153, 2N6156	V_{DRM}	 200 400 600	Volts
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (T_C = -40 to +75°C) Full Cycle Sine Wave 50 to 60 Hz (T_C = +90°C)	$I_{T(RMS)}$	10 5.0	Amp
*Peak Surge Current (One Full Cycle, 60 Hz, T_J = +75°C) preceded and followed by 10 A Current	I_{TSM}	100	Amp
Circuite Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power (T_J = +75°C, Pulse Width = 2.0 μs)	P_{GM}	20	Watts
*Average Gate Power (T_J = +75°C, t = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
*Mounting Torque (6-32 Screw), Note 2	—	8.0	in. lb

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
* Thermal Resistance, Junction to Case	$R\theta_{JC}$	2.0	°C/W
Thermal Resistance Case to Ambient	$R\theta_{CA}$	50	°C/W

*Indicates JEDEC Registered Data.



CASE 90-04

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
*On-State Voltage (Either Direction) I_{TM} = 14 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0 %	V_{TM}	–	1.3	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GT}				mA
MT2 (+), G(+) All Types		–	6.0	50	
MT2 (+), G(–) 2N6151 thru 2N6153		–	6.0	75	
MT2 (–), G(–) All Types		–	10	50	
MT2 (–), G(+) 2N6151 thru 2N6153		–	25	75	
*MT2 (+), G(+); MT2 (–), G(–) T_C = –40°C All Types		–	–	100	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –40°C 2N6151 thru 2N6153		–	–	125	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GT}				Volts
MT2 (+), G(+) All Types		–	0.9	2.0	
MT2 (+), G(–) 2N6151 thru 2N6153		–	0.9	2.5	
MT2 (–), G(–) All Types		–	1.1	2.0	
MT2 (–), G(+) 2N6151 thru 2N6153		–	1.4	2.5	
*MT2 (+), G(+); MT2 (–), G(–) T_C = –40°C All Types		–	–	2.5	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –40°C 2N6151 thru 2N6153		–	–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 100°C					
*MT2 (+), G(+); MT2 (–), G(–) All Types		0.2	–	–	
*MT2 (+), G(–); MT2 (–), G(+) 2N6151 thru 2N6153		0.2	–	–	
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 200 mA	I_H				mA
T_C = 25°C		–	6.0	40	
T_C = –40°C		–	–	75*	
*Turn-On Time Main Terminal Voltage = Rated V_{DRM}, I_{TM} = 14 A Gate Source Voltage = 12 V, R_S = 100 Ohms, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	tgt	–	1.5	2.0	μs
Blocking Voltage Application Rate at Commutation, f = 60 Hz, T_C = 75°C On-State Conditions: I_{TM} = 14 A, Pulse Width = 4.0 ms, di/dt = 5.3 A/ms Off-State Conditions: Main Terminal Voltage = Rated V_{DRM} (200 μs min), Gate Source Voltage = 0 V, R_S = 100 Ω	dv/dt	–	5.0	–	V/μs

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.
   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +230°C.

Trigger devices are recommended for gating on Triacs

Triggers Provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

Electrical Characteristics	For General Usage		For Lamp Dimmer
Symbol	MBS4991	MBS4992	MBS100
V_S =	6.0 –10 V	7.5–9.0 V	3.0–5.0 V
I_S =	350 μA Max	120 μA Max	100–400 μA
V_{S1}–V_{S2} =	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient = 0.02%/°C Typ			

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

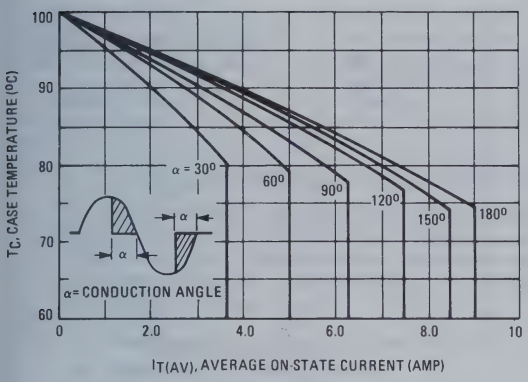


FIGURE 2 – RMS CURRENT DERATING

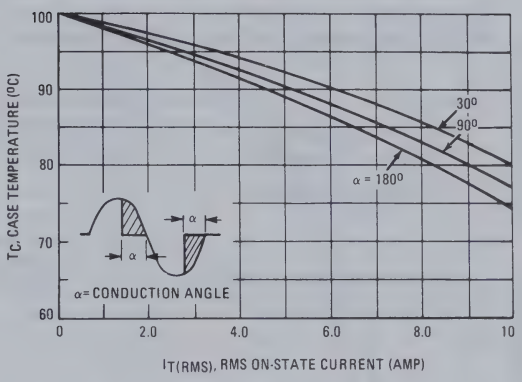


FIGURE 3 – POWER DISSIPATION

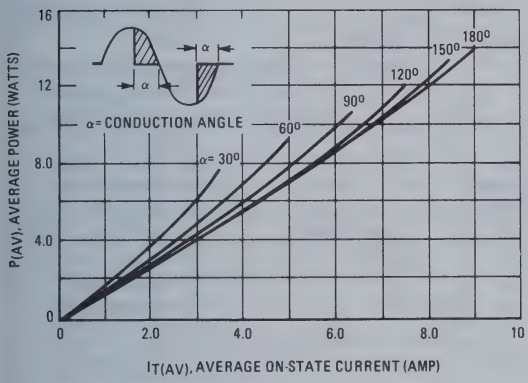


FIGURE 4 – POWER DISSIPATION

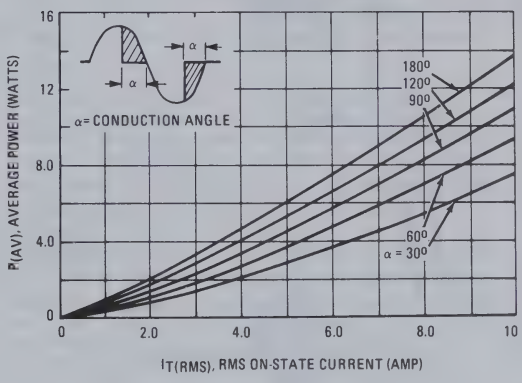


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

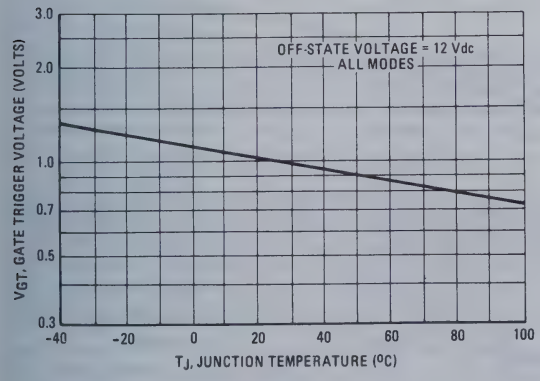


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

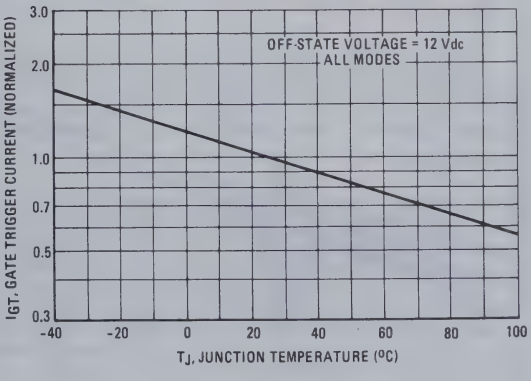


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

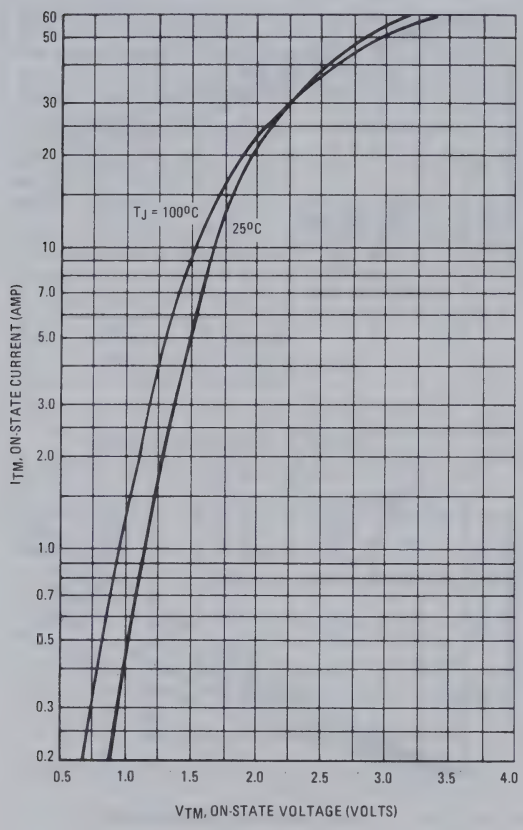


FIGURE 8 – TYPICAL HOLDING CURRENT

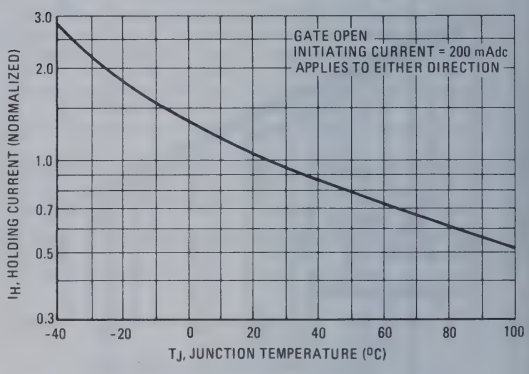


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

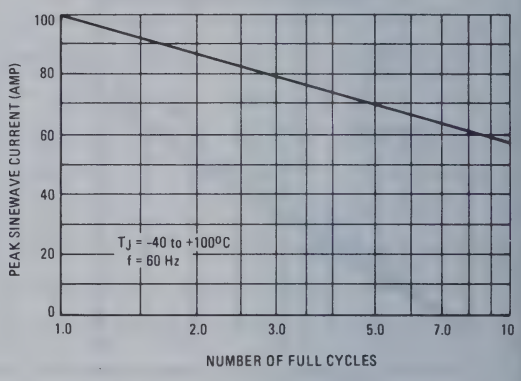
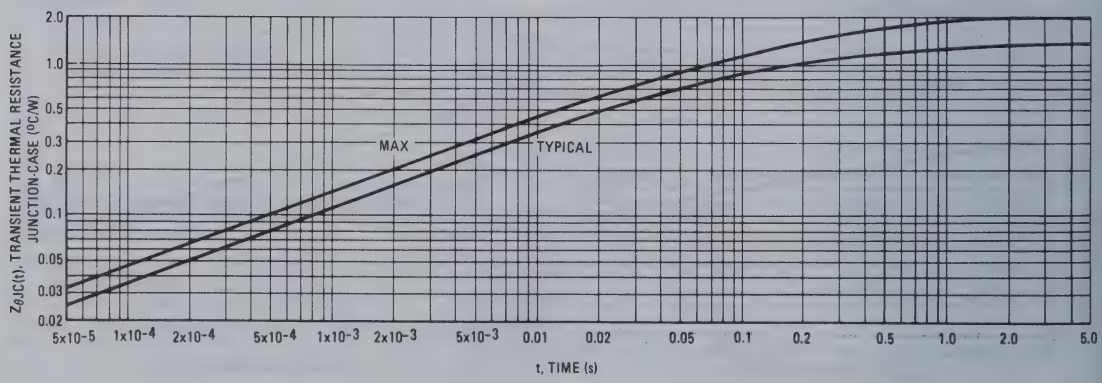


FIGURE 10 – THERMAL RESPONSE



2N6157 (SILICON)
thru
2N6165



SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- Glass Passivated Junctions and Center Gate Fire
- Isolated Stud for Ease of Assembly
- Gate Triggering Guaranteed In All 4 Quadrants

TRIACS (THYRISTORS)

30 AMPERES RMS



2N6157
2N6158
2N6159

CASE 174
TO-203



2N6160
2N6161
2N6162

CASE 175



2N6163
2N6164
2N6165

CASE 235

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage (1) (T_J = –65 to +125°C) 1/2 Sine Wave 50 to 60 Hz, Gate Open	V_{DRM}		Volts
*Peak Principal Voltage 2N6157, 2N6160, 2N6163 2N6158, 2N6161, 2N6164 2N6159, 2N6162, 2N6165		 200 400 600	
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (T_C = –65 to +85°C) (T_C = +100°C) Full Sine Wave, 50 to 60 Hz	$I_{T(RMS)}$	 30 20	Amp
*Peak Surge Current (One Full Cycle of surge current at 60 Hz, preceeded and followed by a 30 ARMS current, T_J = +125°C)	I_{TSM}	250	Amp
Circuit Fusing Considerations (T_J = –65 to +125°C, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
*Peak Gate Power (T_J = +80°C, Pulse Width = 2.0 μs)	P_{GM}	20	Watts
*Average Gate Power (T_J = +80°C, t = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	–65 to +125	°C
*Storage Temperature Range	T_{stg}	–65 to +150	°C
*Stud Torque 2N6160 thru 2N6165	–	30	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.0	°C/W

*Indicates JEDEC Registered Data.

(1) Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

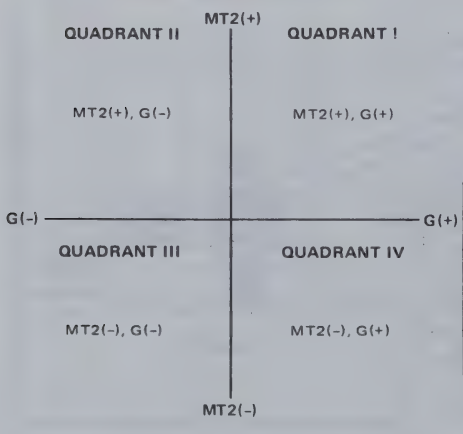
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
* Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 125°C	I_{DRM}	–	–	2.0	mA
*On-State Voltage (Either Direction) I_{TM} = 42 A Peak, Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0 %	V_{TM}	–	1.5	2.0	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms	I_{GT}				mA
MT2 (+), G(+)		–	10	60	
MT2 (+), G(–)		–	13	70	
MT2 (–), G(–)		–	15	70	
MT2 (–), G(+)		–	20	100	
*MT2 (+), G(+); MT2 (–), G(–) T_C = –65°C		–	–	200	
*MT2 (+), G(–); MT2 (–), G(+) T_C = –65°C		–	–	250	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 50 Ohms	V_{GT}				Volts
MT2 (+), G(+)		–	0.7	2.0	
MT2 (+), G(–)		–	0.7	2.1	
MT2 (–), G(–)		–	0.8	2.1	
MT2 (–), G(+)		–	0.9	2.5	
*All Quadrants, T_C = –65°C)		–	–	3.4	
*Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = +125°C		2.0	–	–	
Holding Current Main Terminal Voltage = 12 Vdc, Gate Open Initiating Current = 500 mA	I_H				mA
MT2 (+)		–	5.0	70	
MT2 (–)		–	5.0	80	
*Either Direction, T_C = –65°C		–	–	200	
*Turn-On Time Main Terminal Voltage = Rated V_{DRM}, I_{TM} = 42 A, Gate Source Voltage = 12 V, R_S = 50 Ohms, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	t_{gt}	–	1.0	2.0	μs
Blocking Voltage Application Rate at Commutation, f = 60 Hz, T_C = 85°C On-State Conditions: I_{TM} = 42A, Pulse Width = 4.0 ms, di/dt = 17.5 A/ms Off State Conditions: Main Terminal Voltage = Rated V_{DRM} (200 μs min), Gate Source Voltage = 0 V, R_S = 50 Ω	dv/dt	–	5.0	–	V/μs

*Indicates JEDEC Registered Data.

(1) All voltage polarity reference to main terminal 1.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

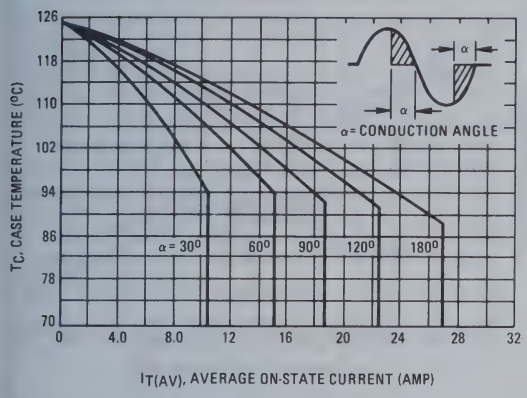


FIGURE 2 – RMS CURRENT DERATING

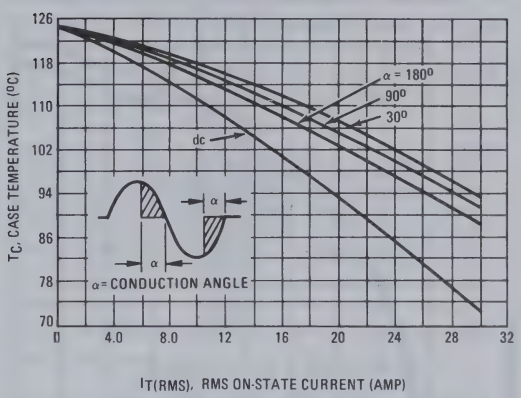


FIGURE 3 – POWER DISSIPATION

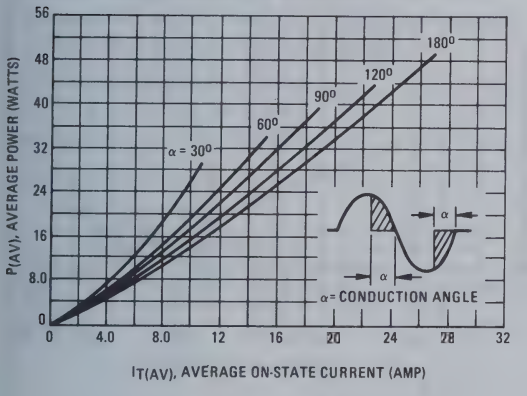


FIGURE 4 – POWER DISSIPATION

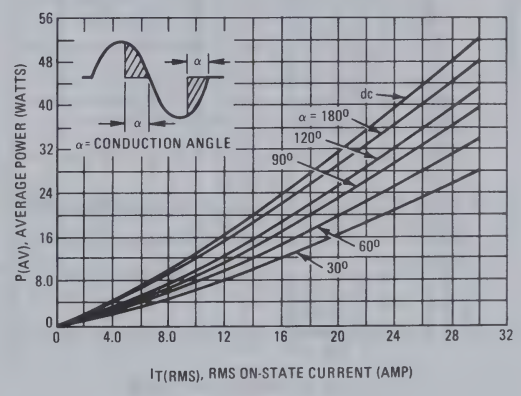


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

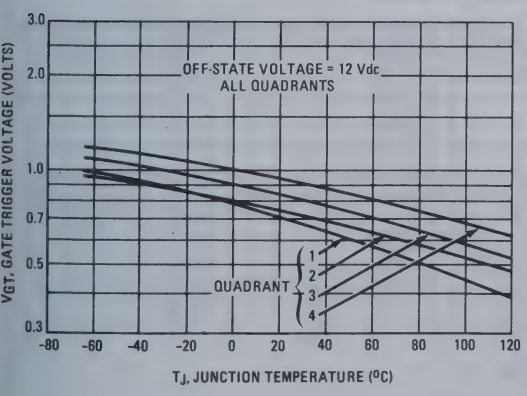


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

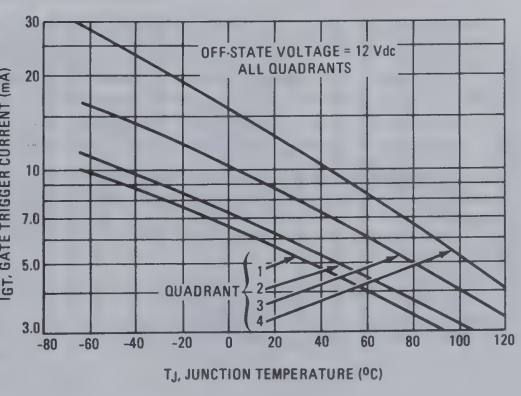


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

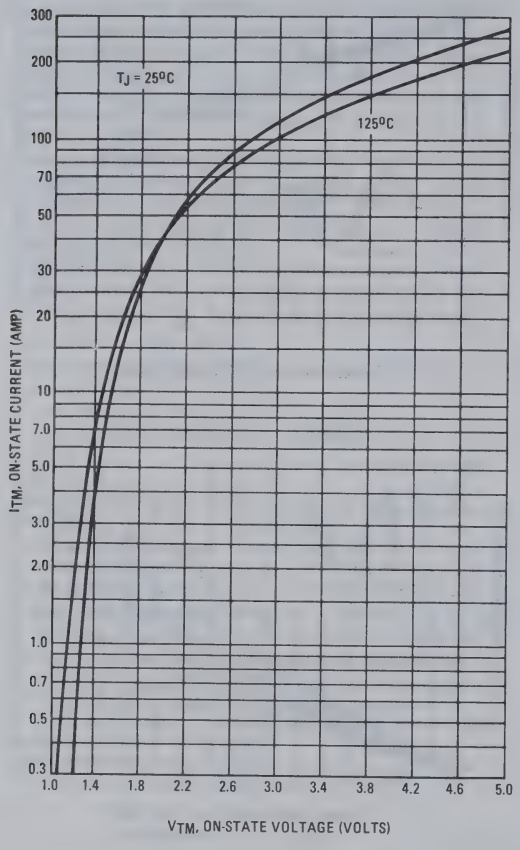


FIGURE 8 – TYPICAL HOLDING CURRENT

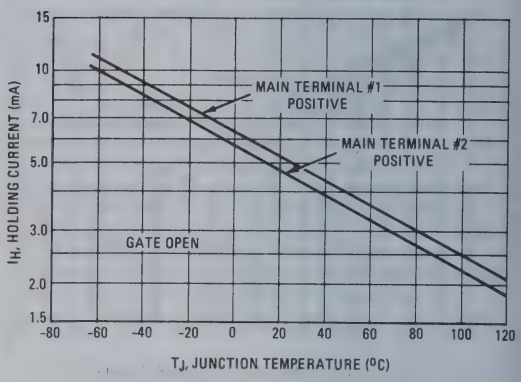


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

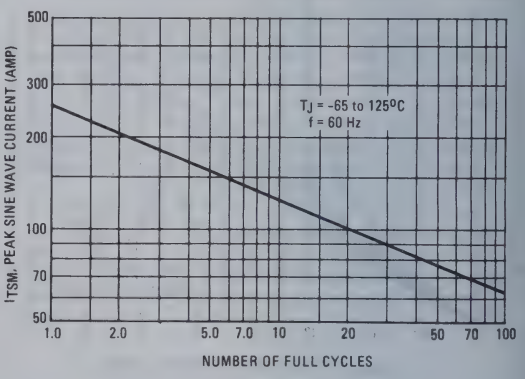
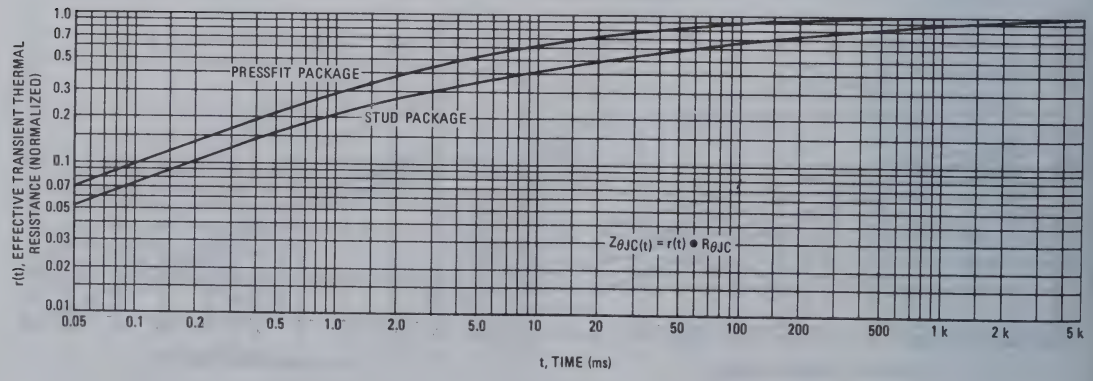
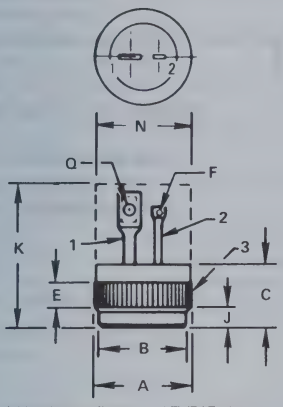


FIGURE 10 – TYPICAL THERMAL RESPONSE



2N6157
2N6158
2N6159



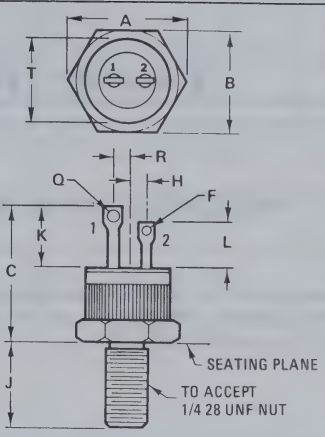
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.726	12.827	0.501	0.505
B	11.811	12.065	0.465	0.475
C	8.39	9.65	0.330	0.380
E	2.54	–	0.100	–
F	0.89	1.72	0.035	0.068
J	2.04	2.46	0.080	0.097
K	–	20.32	–	0.800
N	–	12.95	–	0.510
Q	1.66	2.28	0.065	0.090

All JEDEC dimensions and notes apply

CASE 174-02
TO-203AA

STYLE 3:
TERM. 1. MAIN TERMINAL 1
2. GATE
CASE MAIN TERMINAL 2

2N6160
2N6161
2N6162

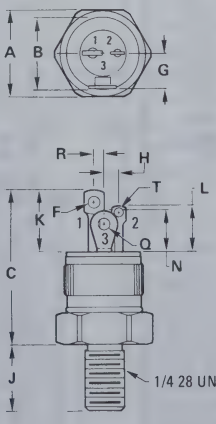


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.34	15.60	0.604	0.614
B	14.00	14.20	0.551	0.559
C	20.70	24.13	0.815	0.950
F	1.40	1.65	0.055	0.065
H	2.29 REF		0.090 REF	
J	10.67	11.56	0.420	0.455
K	9.78	10.54	0.385	0.415
L	6.99	7.75	0.275	0.305
Q	2.03	2.41	0.080	0.095
R	1.65 REF		0.065 REF	
T	12.70	12.83	0.500	0.505

CASE 175

STYLE 3:
TERM. 1. MAIN TERMINAL 1
2. GATE
STUD: MAIN TERMINAL 2

2N6163
2N6164
2N6165



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.00	14.20	0.551	0.559
B	12.73	12.83	0.501	0.505
C	–	26.16	–	1.030
F	2.03	2.41	0.080	0.095
G	–	6.48	–	0.255
H	2.16	2.41	0.085	0.095
J	10.67	11.56	0.420	0.455
K	9.78	10.54	0.385	0.415
L	6.99	7.75	0.275	0.305
N	6.48	6.99	0.255	0.275
Q	3.43	3.81	0.135	0.150
R	1.52	1.78	0.060	0.070
T	1.40	1.65	0.055	0.065

CASE 235

STYLE 2:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2
STUD-ISOLATED

2N6166 (SILICON)

The RF Line

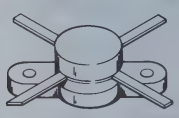
NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 200 MHz

- High Output Power Capability — 100 Watts Output @ f = 150 MHz
- Balanced Emitter Construction to Provide the Designer With the Device Technology that Assures Ruggedness and Resists Transistor Damage Caused by Load Mismatch.
- Flange Case for Ease of Mounting and Improved Thermal Conductivity

100 WATTS — 150 MHz

NPN SILICON RF POWER TRANSISTOR



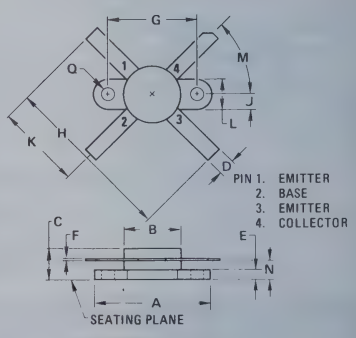
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	9.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	117 0.667	Watts $W/^oC$
Storage Temperature Range	Tstg	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	11.81	12.07	0.465	0.475
C	5.82	6.73	0.229	0.265
D	2.16	3.94	0.085	0.155
E	2.13	2.54	0.084	0.100
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	35.56	38.10	1.400	1.500
J	3.12	3.23	0.123	0.127
K	17.78	19.05	0.700	0.750
L	6.22	6.48	0.245	0.255
M	40^0	50^0	40^0	50^0
N	3.66	4.32	0.144	0.170
Q	2.97	3.12	0.117	0.123

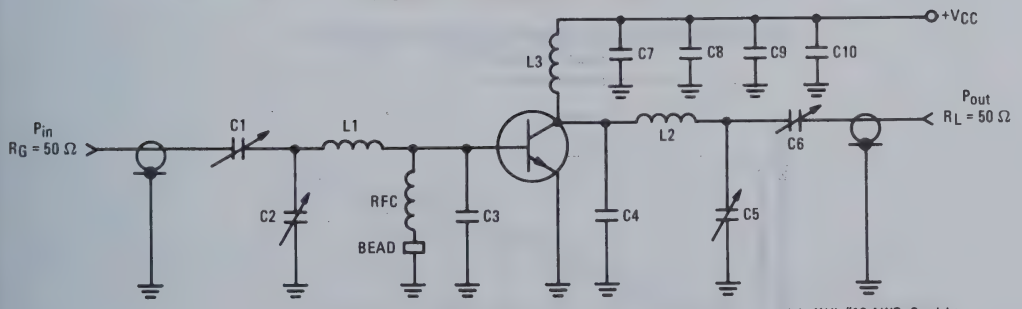
CASE 211-02

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

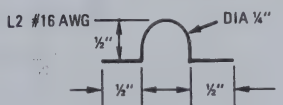
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	65	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	3.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	130	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (P_{out} = 100 W, V_{CC} = 28 Vdc, I_C (Max) = 5.95 Adc, f = 150 MHz)	G_{PE}	6.0	–	dB
Common-Emitter Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 13.5 V, f = 150 MHz)	G_{PE}	4.5	–	dB
Collector Efficiency (P_{out} = 100 W, V_{CC} = 28 Vdc, I_C (Max) = 5.95 Adc, f = 150 MHz)	η	60	–	%

FIGURE 1 – 150 MHz TEST CIRCUIT

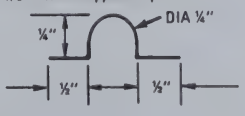


C1, C6 2.7-30 pF, Arco 461 or Equivalent
C2, C5 9.0-180 pF, Arco 463 or Equivalent
C3 100 pF Underwood
C4 25 pF Underwood
C7 0.01 μF Ceramic Disc
C8 0.1 μF Ceramic Disc
C9 2400 pF Button
C10 5.0 μF/50 V
RFC 0.15 μH J. W. Miller
BEAD: FERROXCUBE 56-590-65-3B

L1 1¼" #16 AWG, Straight



L3 1/8" Wide Copper Strap



OUTPUT POWER versus FREQUENCY

FIGURE 2 – V_{CC} = 28 Vdc

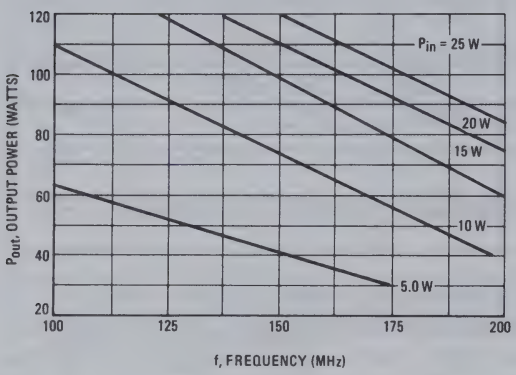


FIGURE 3 – V_{CC} = 13.5 Vdc

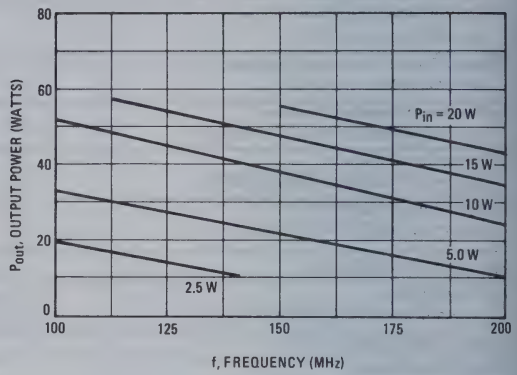


FIGURE 4 – OUTPUT POWER versus INPUT POWER

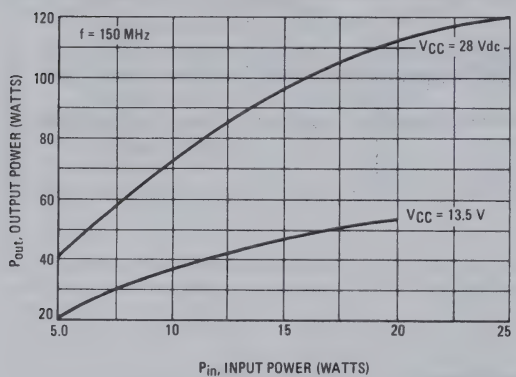


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

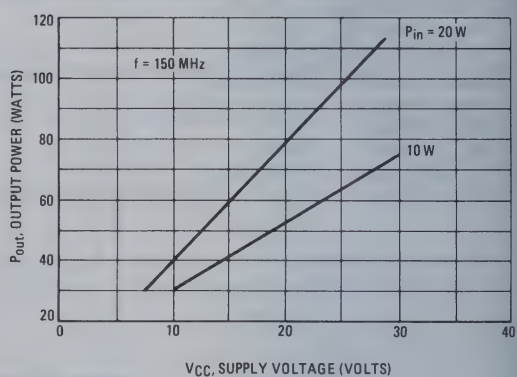


FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

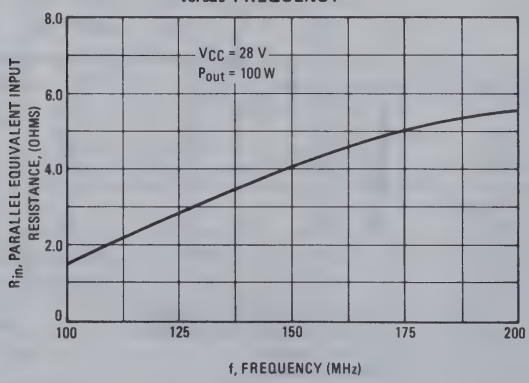


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

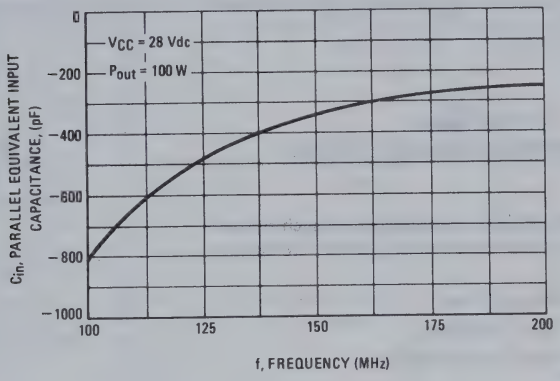
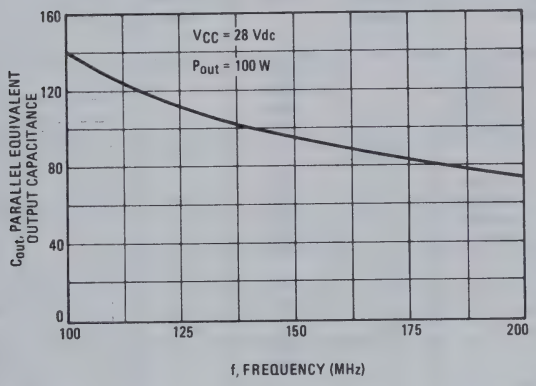


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



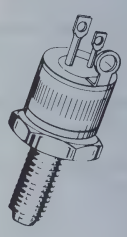
2N6167 (SILICON)
thru
2N6170

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies; battery chargers; temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current – I_{TSM} = 240 Amp
- Rugged Construction in Isolated Stud Package

THYRISTORS
PNPN
20 AMPERES RMS
100-600 VOLTS



MAXIMUM RATINGS

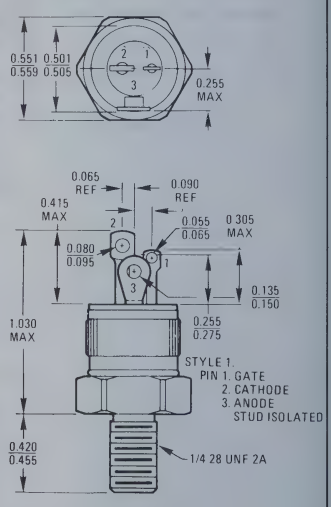
Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage (1) (T_J = -40 to +100°C) 1/2 Sine Wave, 50 to 400 Hz, Gate Open	V_{RRM}		Volts
2N6167		100	
2N6168		200	
2N6169		400	
2N6170		600	
*Non-Repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)	V_{RSM}		Volts
2N6167		150	
2N6168		250	
2N6169		450	
2N6170		650	
*Average Forward Current (T_C = -40 to +65°C) (+85°C)	$I_{T(AV)}$	13 6.5	Amp
*Peak Surge Current (One cycle, 60 Hz) (T_C = +65°C) (1.5 ms pulse @ T_J = 100°C Preceded and followed by no current or Voltage	I_{TSM}	240 560	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)	I^2t	235	A^2s
*Peak Gate Power	P_{GM}	5.0	Watts
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GFM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
*Stud Torque	–	30	in. lb.

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta JC$	1.5	°C/W

*Indicates JEDEC Registered Data.

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.



Maximum Lead temperature for Soldering Purposes:
230°C at a distance ≥ 1/16" from case for 10 s.

CASE 235

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (T_J = 100°C)	V_{RRM}				Volts
2N6167		100	–	–	
2N6168		200	–	–	
2N6169		400	–	–	
2N6170		600	–	–	
*Peak Forward Blocking Current (Rated V_{DRM}, gate open, T_J = 100°C)	I_{DRM}				mA
2N6167		–	1.0	2.0	
2N6168		–	1.0	2.5	
2N6169		–	1.0	3.0	
2N6170		–	1.0	4.0	
*Peak Reverse Blocking Current (Rated V_{RRM}, gate open, T_J = 100°C)	I_{RRM}				mA
2N6167		–	1.0	2.0	
2N6168		–	1.0	2.5	
2N6169		–	1.0	3.0	
2N6170		–	1.0	4.0	
*Peak Forward "On" Voltage (I_{TM} = 41 A Peak)	V_{TM}	–	1.5	1.7	Volts
Gate Trigger Current, Continuous dc (V_{AK} = 12 V, R_L = 24 Ω) *T_C = -40°C	I_{GT}	–	–	75	mA
T_C = 25°C		–	2.1	40	
Gate Trigger Voltage, Continuous dc (V_{AK} = 12 V, R_L = 24 Ω)	V_{GT}				Volts
*T_C = -40°C		–	0.8	2.5	
T_C = 25°C		–	0.63	1.6	
Holding Current (V_{AK} = 12 V, Gate Open) *T_C = -40°C	I_H	–	–	90	mA
T_C = 25°C		–	3.5	50	
Peak Initiating On-State Current = 200 mA					
*Turn-On Time (t_d + t_r) (I_{TM} = 41 Adc, Rated V_{DRM}) I_{GT} = 200 mAdc, Rise Time = 0.05 μs, Pulse Width = 10 μs)	t_{on}	–	–	1.0	μs
Turn-Off Time	t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)		–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)		–	25	–	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs

*Indicates JEDEC Registered Data.

FIGURE 1 – AVERAGE CURRENT DERATING

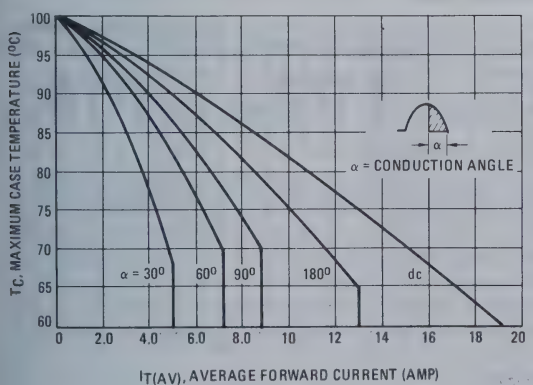


FIGURE 2 – POWER DISSIPATION

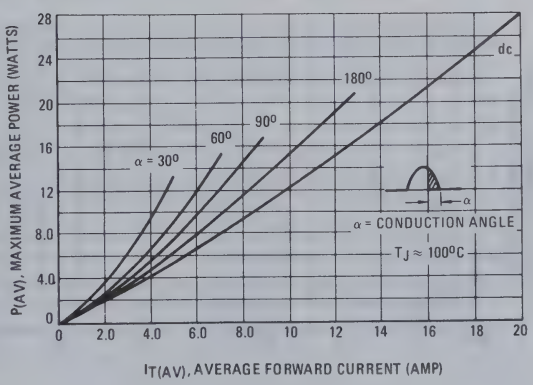


FIGURE 3 – MAXIMUM ON-STATE CHARACTERISTICS

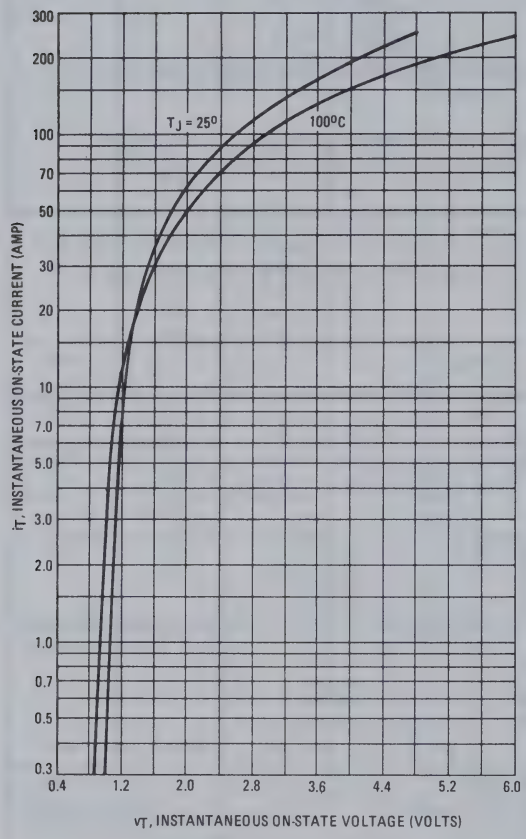


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CURRENT

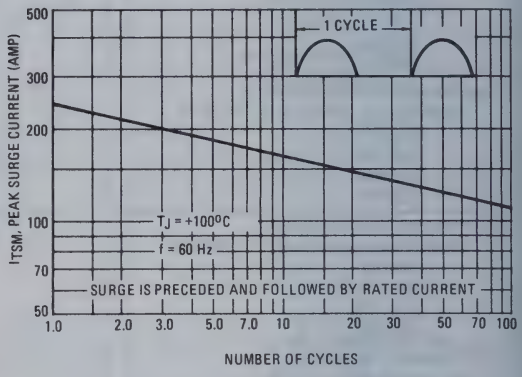


FIGURE 5 – CHARACTERISTICS AND SYMBOLS

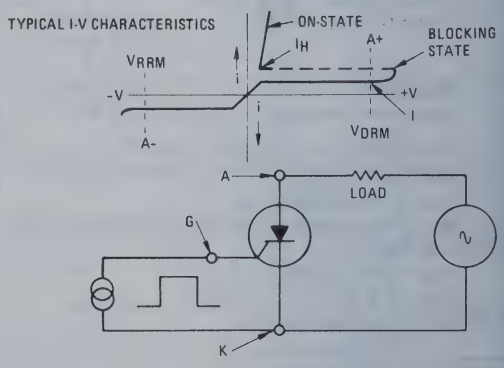


FIGURE 6 – THERMAL RESPONSE

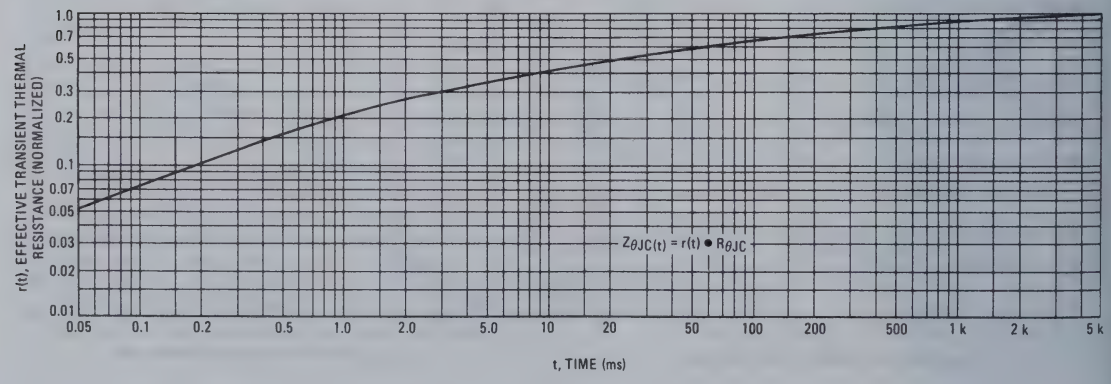


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

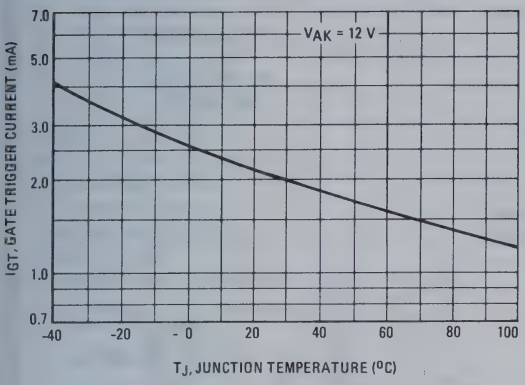


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE

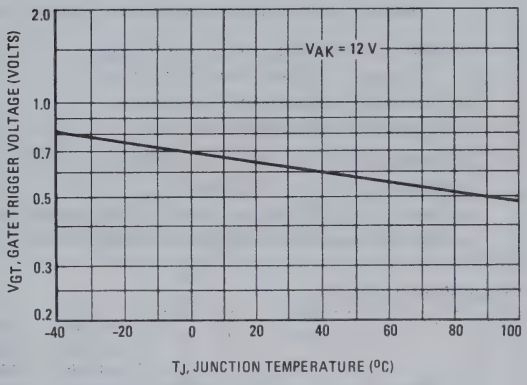
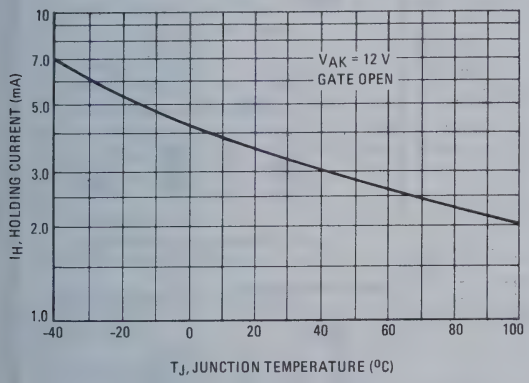


FIGURE 9 – TYPICAL HOLDING CURRENT



Selected Thyristor-Trigger Application Notes

AN-240 – SCR Power Control Fundamentals
AN-295 – Suppressing RFI in Thyristor Circuits
AN-422 – Testers for Thyristors and Trigger Diodes
AN-453 – Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

2N6171 thru 2N6174 (SILICON)

For Specifications, See 2N3870, Volume I.

2N6182 thru 2N6185 (SILICON)
2N6186 thru 2N6189

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 10 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration
- 2N6182 thru 2N6185 Complement to NPN 2N5477 thru 2N5480
  2N6186 thru 2N6189 Complement to NPN 2N5346 thru 2N5349

10 AMPERE POWER TRANSISTORS

PNP SILICON

80-100 VOLTS
60 WATTS

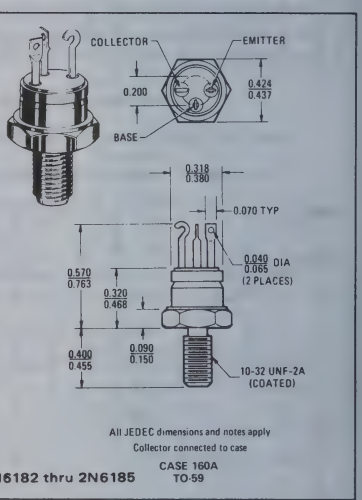
*MAXIMUM RATINGS

Rating	Symbol	2N6182 2N6183 2N6186 2N6187	2N6184 2N6185 2N6188 2N6189	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	60		Watts
Derate above 25°C		343		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

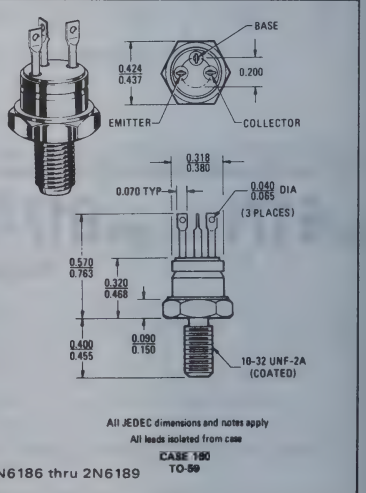
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

*Indicates JEDEC Registered Data



All JEDEC dimensions and notes apply
Collector connected to case

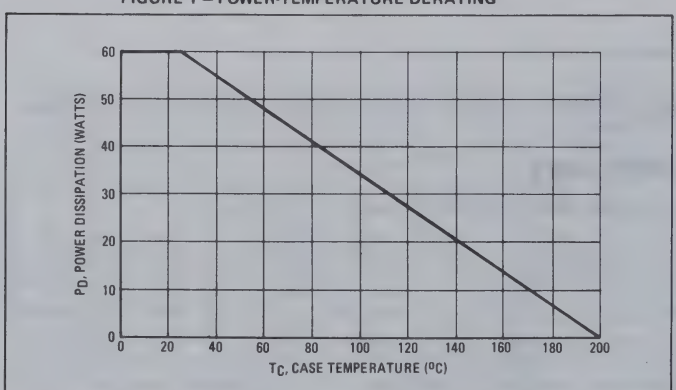
2N6182 thru 2N6185 — CASE 160A TO-59



All JEDEC dimensions and notes apply
All leads isolated from case

2N6186 thru 2N6189 — CASE 180 TO-59

FIGURE 1 — POWER-TEMPERATURE DERATING



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

2N6182 thru 2N6185, 2N6186 thru 2N6189 (continued)

*** ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)		–	$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6182, 83, 86, 87			80	–	
	2N6184, 85, 88, 89			100	–	
Collector Cutoff Current		–	I_{CEO}			μAdc
(V_{CE} = 75 Vdc, I_B = 0)	2N6182, 83, 86, 87			–	100	
(V_{CE} = 90 Vdc, I_B = 0)	2N6184, 85, 88, 89			–	100	
Collector Cutoff Current		12	I_{CEX}			μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6182, 83, 86, 87			–	10	
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6184, 85, 88, 89			–	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6182, 83, 86, 87			–	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6184, 85, 88, 89			–	1.0	
Collector Cutoff Current		–	I_{CBO}			μAdc
(V_{CB} = Rated V_{CB}, I_E = 0)				–	10	
Emitter Cutoff Current		–	I_{EBO}			μAdc
(V_{BE} = 6.0 Vdc, I_C = 0)				–	100	
ON CHARACTERISTICS (1)						
DC Current Gain		8	h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)	2N6182, 84, 86, 88			30	–	
	2N6183, 85, 87, 89			60	–	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N6182, 84, 86, 88			30	120	
	2N6183, 85, 87, 89			60	240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N6182, 84, 86, 88			20	–	
	2N6183, 85, 87, 89			40	–	
Collector-Emitter Saturation Voltage		9, 10, 11	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)				–	0.7	
(I_C = 10 Adc, I_B = 1.0 Adc)				–	1.2	
Base-Emitter Saturation Voltage		10, 11	$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)				–	1.2	
(I_C = 10 Adc, I_B = 1.0 Adc)				–	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product (2)		–	f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{Test} = 10 MHz)				30	–	
Output Capacitance		7	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)				–	300	
Input Capacitance		7	C_{ib}			pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)				–	1250	

SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 3.0 Vdc,	2, 3	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)		t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2, 6	t_s	–	2.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)		t_f	–	200	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{Test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

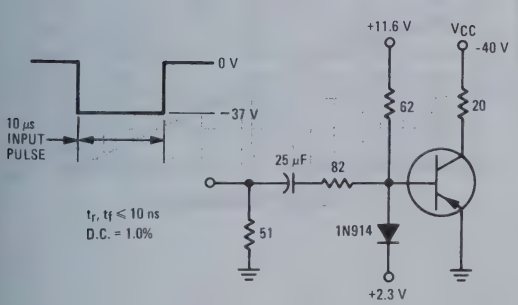


FIGURE 3 – TURN-ON TIME

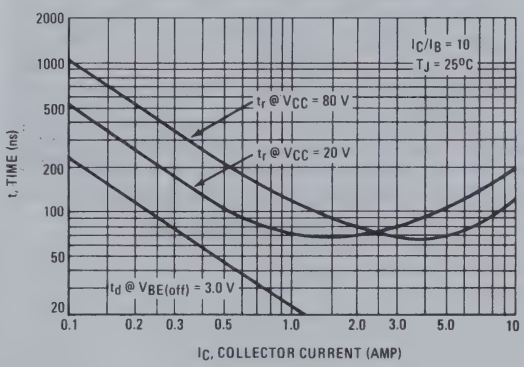


FIGURE 4 – THERMAL RESPONSE

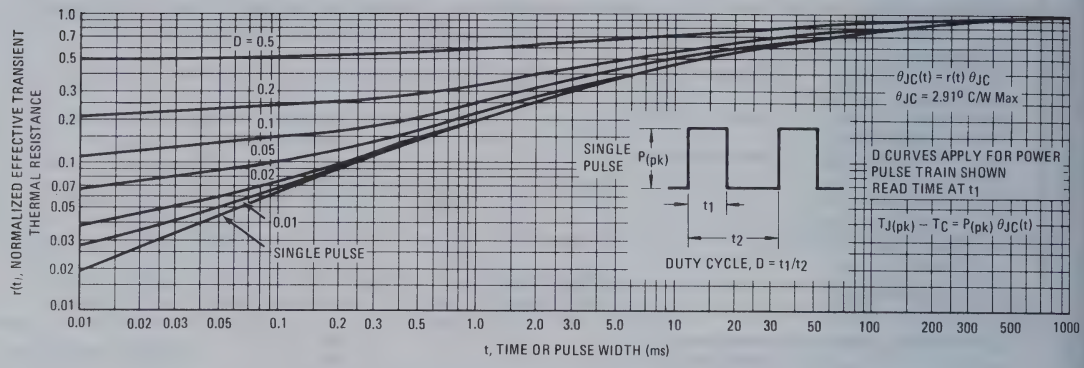
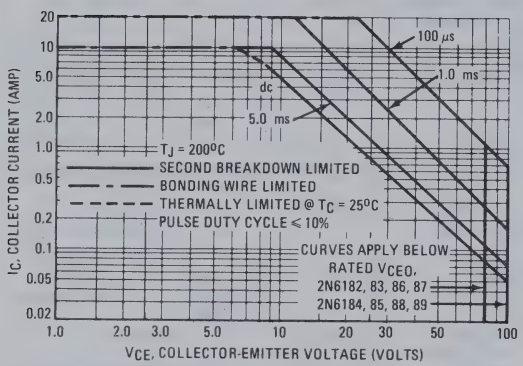


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitaitons imposed by second breakdown.

FIGURE 6 – TURN OFF TIME

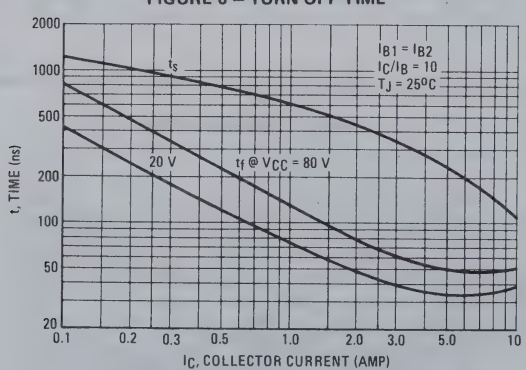


FIGURE 7 – CAPACITANCE versus VOLTAGE

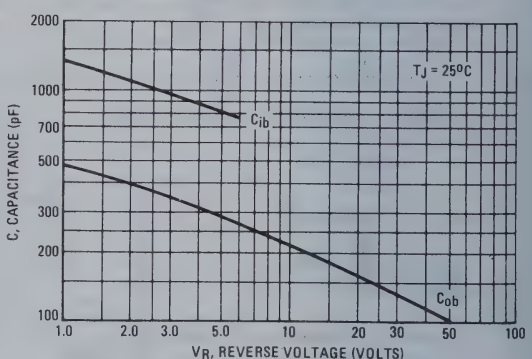


FIGURE 8 – DC CURRENT GAIN

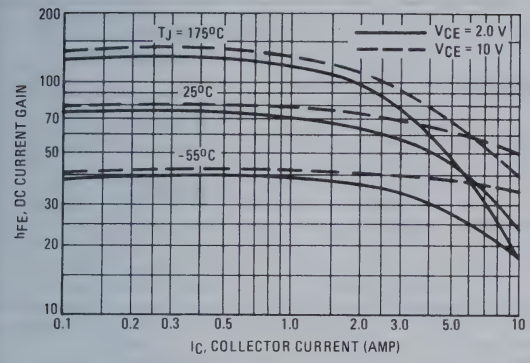


FIGURE 9 – COLLECTOR SATURATION REGION

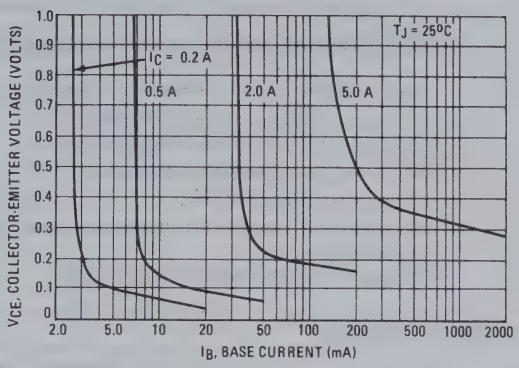


FIGURE 10 – "ON" VOLTAGES

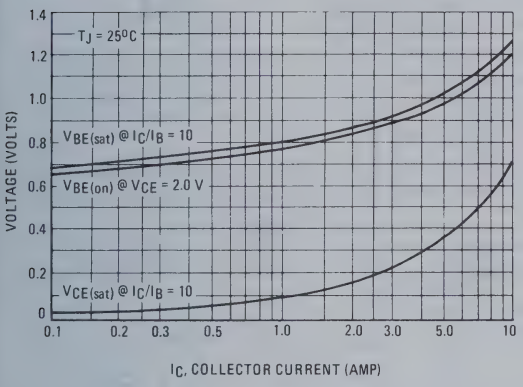


FIGURE 11 – TEMPERATURE COEFFICIENTS

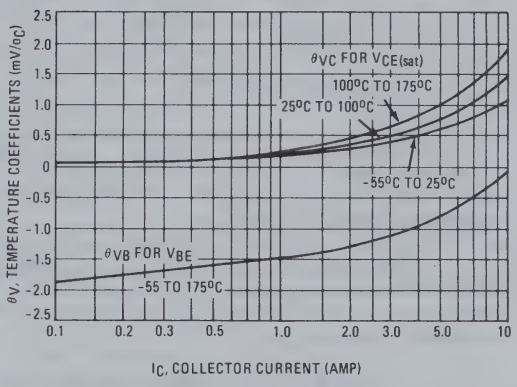


FIGURE 12 – COLLECTOR CUT-OFF REGION

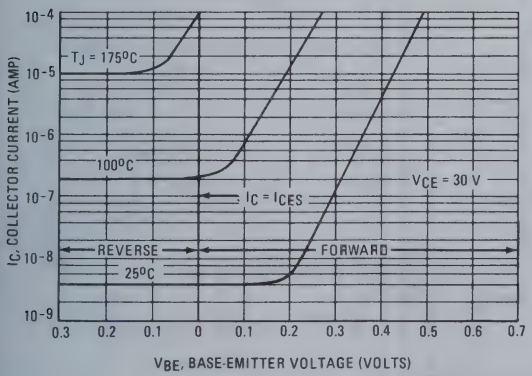
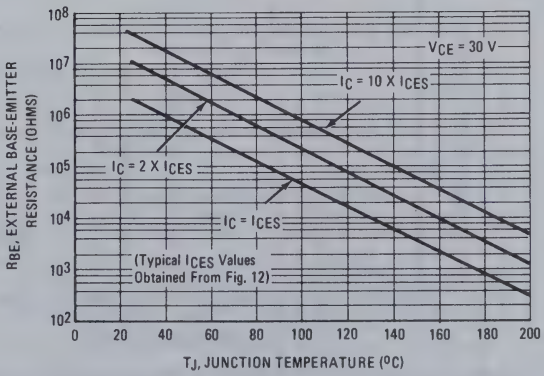


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N6190 (SILICON)
thru
2N6193

MEDIUM-POWER PNP SILICON TRANSISTORS

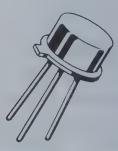
. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space Limited Applications
- Complement to NPN 2N5336 thru 2N5339

5 AMPERE POWER TRANSISTORS

PNP SILICON

80-100 VOLTS
10 WATTS



***MAXIMUM RATINGS**

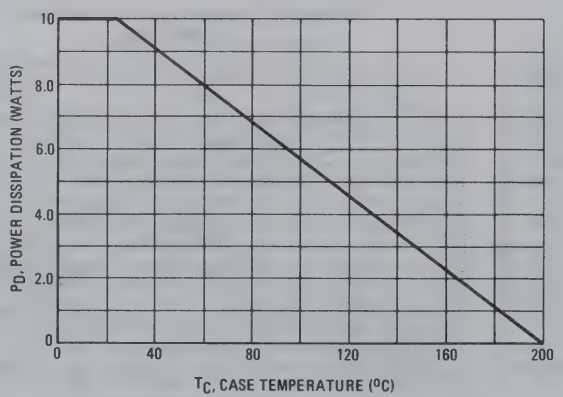
Rating	Symbol	2N6190 2N6191	2N6192 2N6193	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	10		Watts
Derate above 25^oC		57.1		$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

THERMAL CHARACTERISTICS

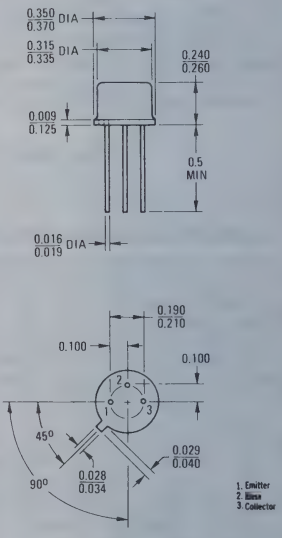
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	$^oC/W$

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



All JEDEC dimensions and notes apply

CASE 79
TO-39

* ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)		–	$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6190, 2N6191			80	–	
	2N6192, 2N6193			100	–	
Collector Cutoff Current		–	I_{CEO}			μAdc
(V_{CE} = 75 Vdc, I_B = 0)	2N6190, 2N6191			–	100	
(V_{CE} = 90 Vdc, I_B = 0)	2N6192, 2N6193			–	100	
Collector Cutoff Current		12	I_{CEX}			μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6190, 2N6191			–	10	
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6192, 2N6193			–	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6190, 2N6191			–	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6192, 2N6193			–	1.0	
Collector Cutoff Current		–	I_{CBO}			μAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N6190, 2N6191			–	10	
(V_{CB} = 100 Vdc, I_E = 0)	2N6192, 2N6193			–	10	
Emitter Cutoff Current		–	I_{EBO}			μAdc
(V_{BE} = 6.0 Vdc, I_C = 0)				–	100	
ON CHARACTERISTICS (1)						
DC Current Gain		8	h_{FE}			–
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N6190, 2N6192			30	–	
	2N6191, 2N6193			60	–	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N6190, 2N6192			30	120	
	2N6191, 2N6193			60	240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N6190, 2N6192			20	–	
	2N6191, 2N6193			40	–	
Collector-Emitter Saturation Voltage		9,10,11	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)				–	0.7	
(I_C = 5.0 Adc, I_B = 0.5 Adc)				–	1.2	
Base-Emitter Saturation Voltage		10,11	$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)				–	1.2	
(I_C = 5.0 Adc, I_B = 0.5 Adc)				–	1.8	
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product (2)		–	f_T			MHz
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{Test} = 10 MHz)				30	–	
Output Capacitance		7	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)				–	300	
Input Capacitance		7	C_{ib}			pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)				–	1250	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 3.0 Vdc,	2,3	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)		t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	–	2.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)		t_f	–	200	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) $f_T = |h_{fe}| \cdot f_{Test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

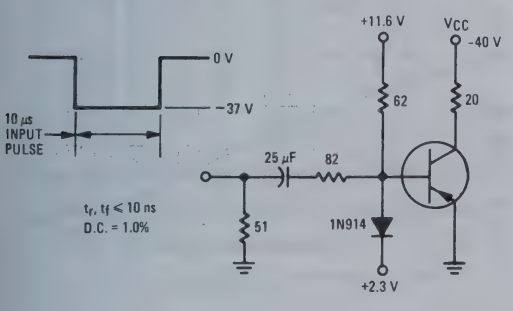


FIGURE 3 – TURN ON TIME

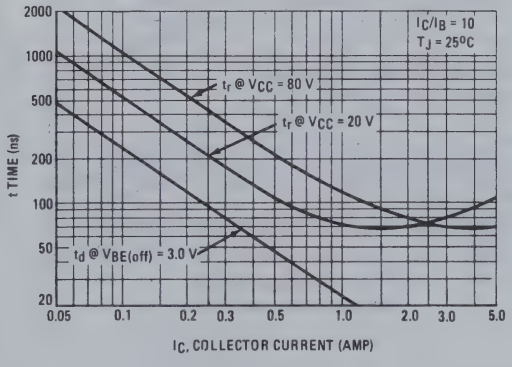


FIGURE 4 – THERMAL RESPONSE

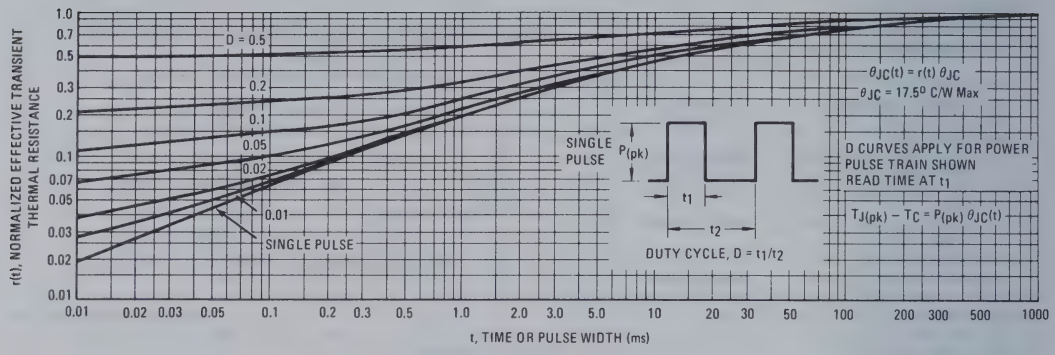
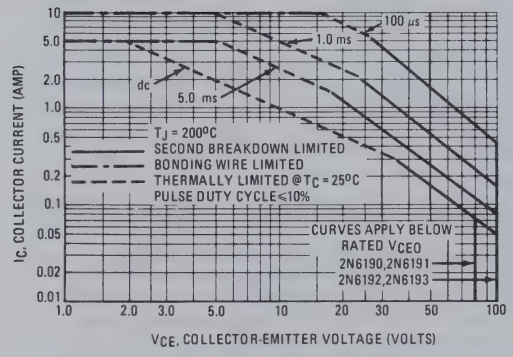


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitaitons imposed by second breakdown.

FIGURE 6 – TURN-OFF TIME

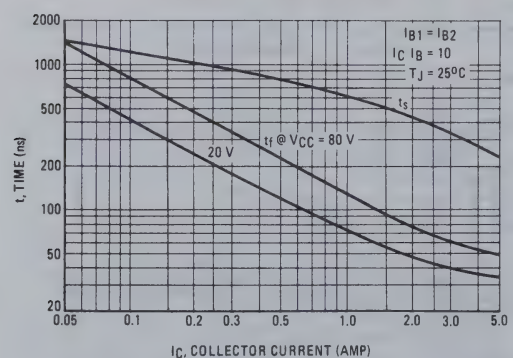


FIGURE 7 – CAPACITANCE versus VOLTAGE

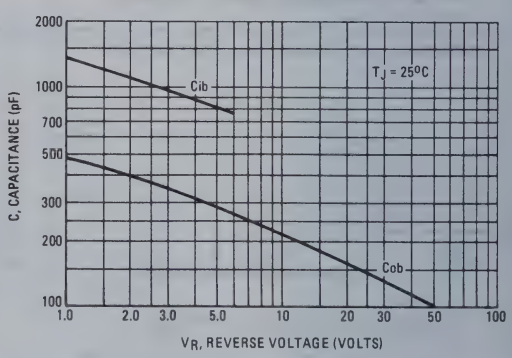


FIGURE 8 – DC CURRENT GAIN

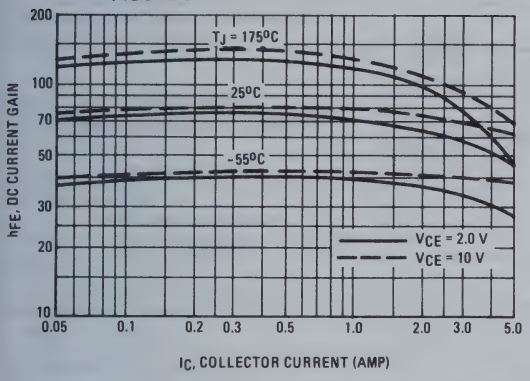


FIGURE 9 – COLLECTOR SATURATION REGION

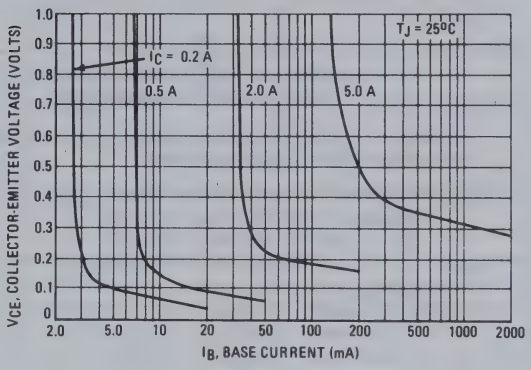


FIGURE 10 – ON VOLTAGES

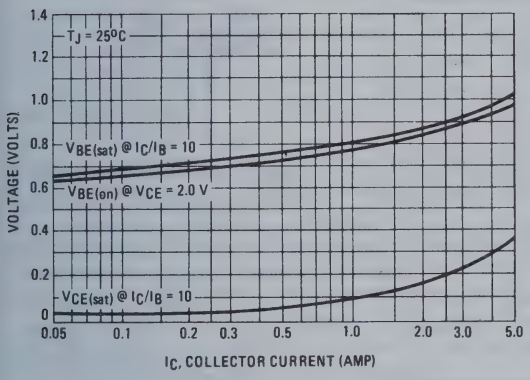


FIGURE 11 – TEMPERATURE COEFFICIENTS

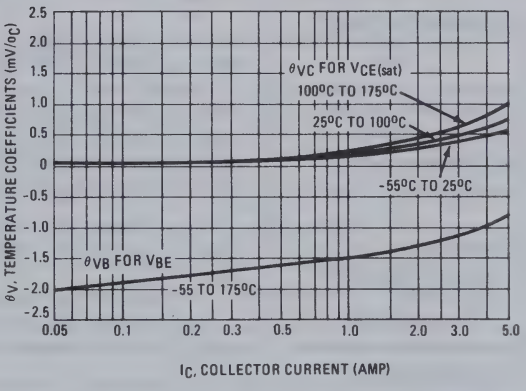


FIGURE 12 – COLLECTOR CUT-OFF REGION

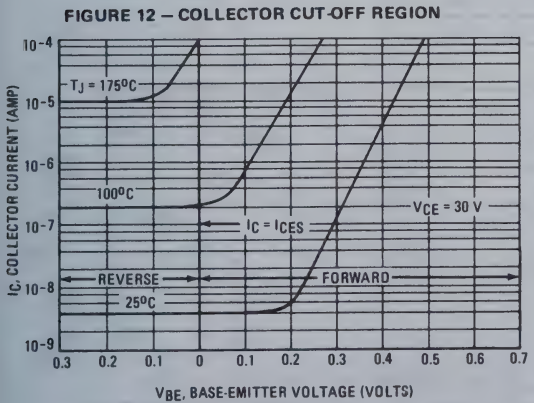
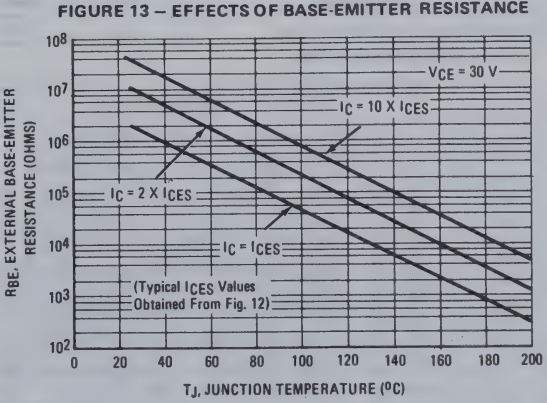


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N6226 (SILICON)
2N6227
2N6228

HIGH-VOLTAGE HIGH-POWER PNP SILICON TRANSISTORS

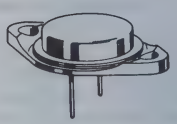
. . . designed for use in high-power audio amplifier applications and high-voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) – 2N6226
  = 120 Vdc (Min) – 2N6227
  = 140 Vdc (Min) – 2N6228
- DC Current Gain – @ I_C = 3.0 Adc
  h_{FE} = 25 (Min) – 2N6226
  = 20 (Min) – 2N6227
  = 15 (Min) – 2N6228
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 3.0 Adc
- Complement to NPN Transistors 2N5758, 2N5759, 2N5760

6 AMPERE POWER TRANSISTORS

PNP SILICON

100-120-140 VOLTS
150 WATTS



*MAXIMUM RATINGS

Rating	Symbol	2N6226	2N6227	2N6228	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current – Continuous	I_C	← 6.0 →			Adc
Peak		← 10 →			
Base Current	I_B	← 4.0 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 150 →			Watts
Derate above 25°C		← 0.857 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

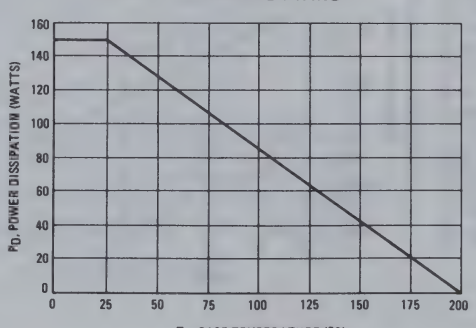
*Indicates JEDEC Registered Data.

All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

FIGURE 1 – POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

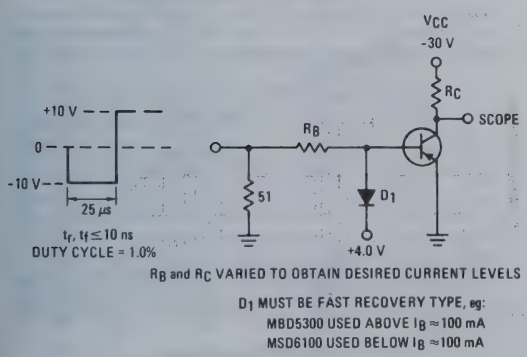
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N6226		100	–	
	2N6227		120	–	
	2N6228		140	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6226		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N6227		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N6228		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)			–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N6226		25	100	
	2N6227		20	80	
	2N6228		15	60	
(I_C = 6.0 Adc, V_{CE} = 2.0 Vdc	All Types		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)			–	1.0	
(I_C = 6.0 Adc, I_B = 1.2 Adc)			–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			–	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 0.5 Adc, V_{CE} = 20 Vdc, f_{test} = 0.5 MHz)			1.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	450	
Small-Signal Current Gain		h_{fe}			–
(I_C = 2.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			15	–	–

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

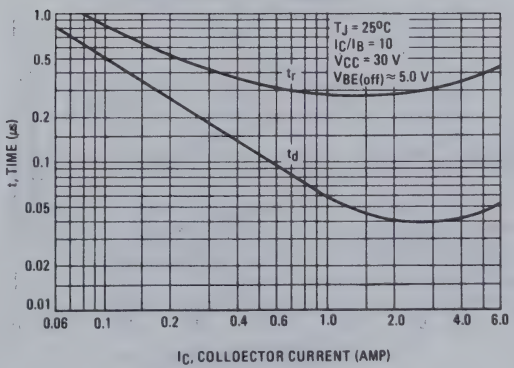


FIGURE 4 – THERMAL RESPONSE

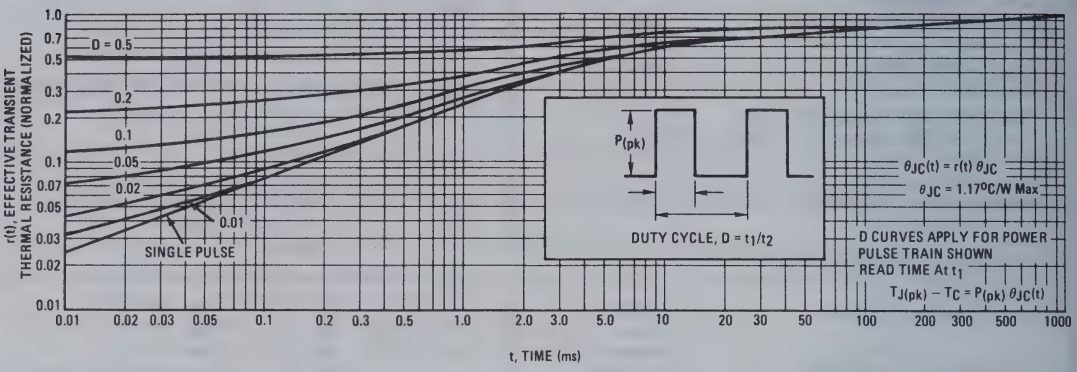
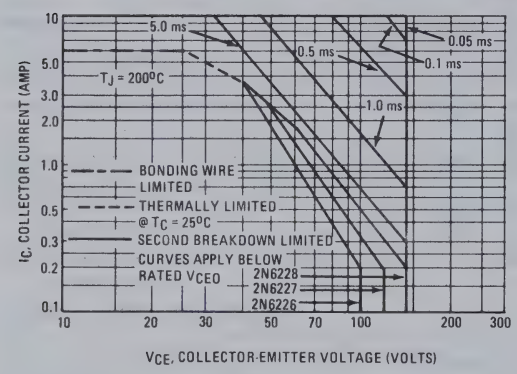


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

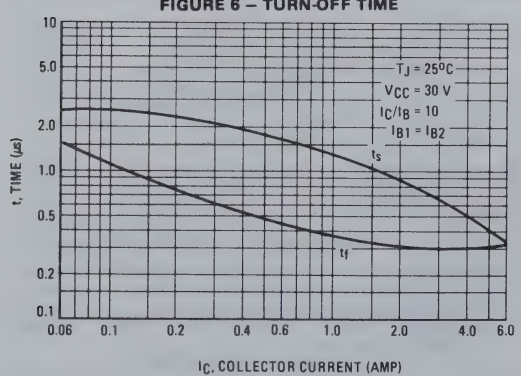


FIGURE 7 – CAPACITANCE

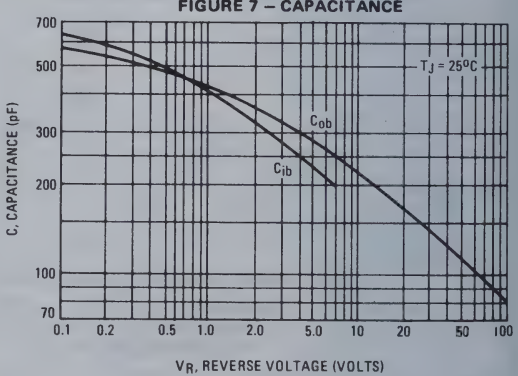


FIGURE 8 – DC CURRENT GAIN

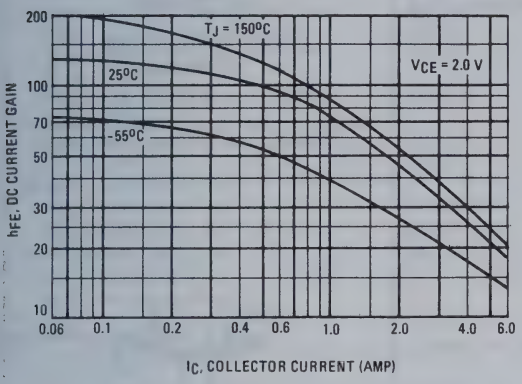


FIGURE 9 – COLLECTOR SATURATION REGION

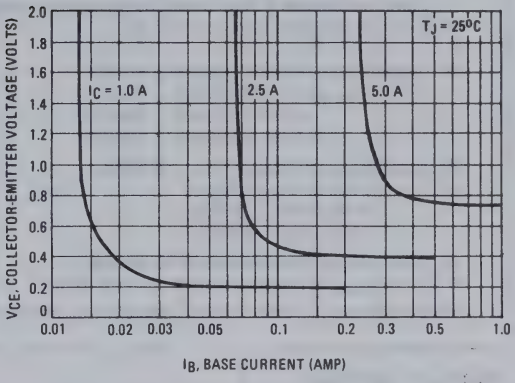


FIGURE 10 – "ON" VOLTAGES

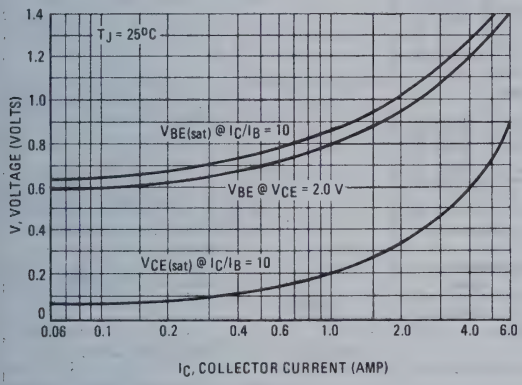


FIGURE 11 – TEMPERATURE COEFFICIENTS

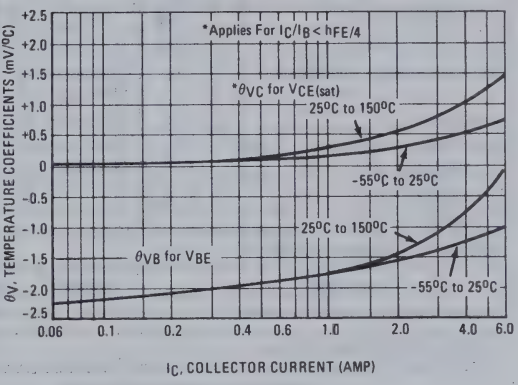


FIGURE 12 – COLLECTOR CUT-OFF REGION

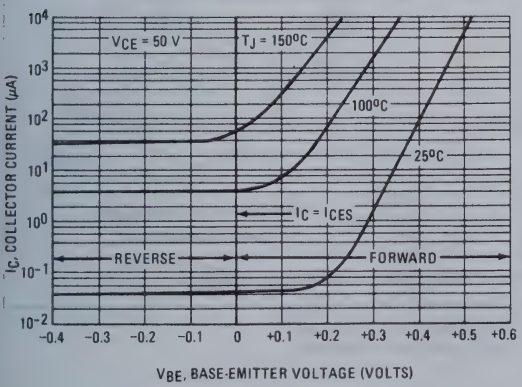
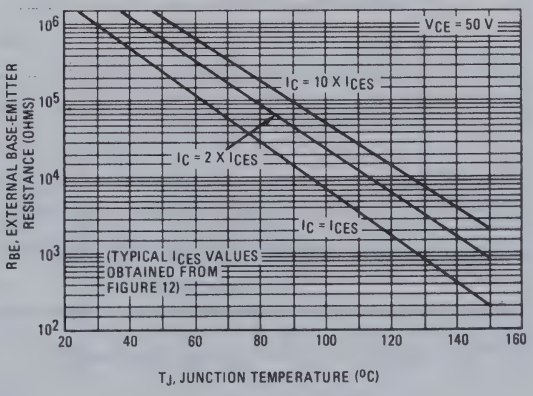


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N6229 (SILICON)
2N6230
2N6231

HIGH-VOLTAGE HIGH-POWER PNP SILICON TRANSISTORS

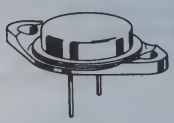
. . . designed for use in high power audio amplifier applications and high voltage switching regulator circuits.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 100 Vdc (Min) — 2N6229
  = 120 Vdc (Min) — 2N6230
  = 140 Vdc (Min) — 2N6231
- High DC Current Gain — @ I_C = 5.0 Adc
  h_{FE} = 25 (Min) — 2N6229
  = 20 (Min) — 2N6230
  = 15 (Min) — 2N6231
- Low Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 7.5 Adc
- Complements to NPN 2N5632, 2N5633 and 2N5634

10 AMPERE POWER TRANSISTORS

PNP SILICON

100, 120, 140 VOLTS
150 WATTS



*MAXIMUM RATINGS

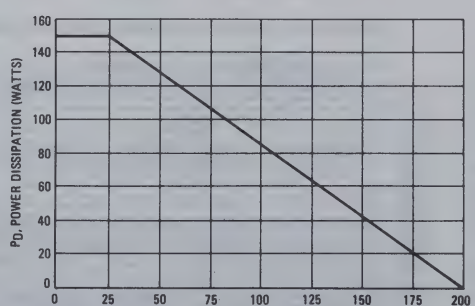
Rating	Symbol	2N6229	2N6230	2N6231	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous Peak	I_C	← 10 → ← 15 →			Adc
Base Current	I_B	← 5.0 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 150 → ← 0.857 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← − 65 to +200 →			°C

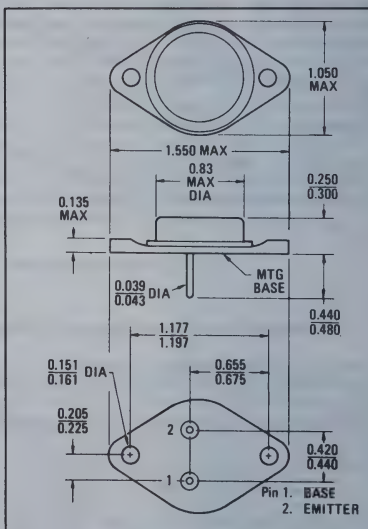
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

2N6229, 2N6230, 2N6231 (continued)

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

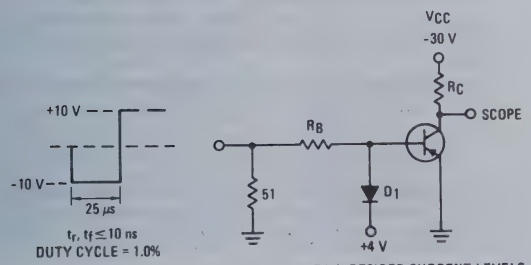
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N6229		100	–	
	2N6230		120	–	
	2N6231		140	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6229		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N6230		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N6231		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6229		–	1.0	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6230		–	1.0	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6231		–	1.0	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6229		–	5.0	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6230		–	5.0	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6231		–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N6229		–	1.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N6230		–	1.0	
(V_{CB} = 140 Vdc, I_E = 0)	2N6231		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N6229		25	100	
	2N6230		20	80	
	2N6231		15	60	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	All		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 7.5 Adc, I_B = 0.75 Adc)			–	1.0	
(I_C = 10 Adc, I_B = 2.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 7.5 Adc, I_B = 0.75 Adc)			–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			–	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 1.0 Adc, V_{CE} = 20 Vdc), f_{test} = 0.5 MHz)			1.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	600	
Small-Signal Current Gain		h_{fe}			–
(I_C = 2.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			15	–	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

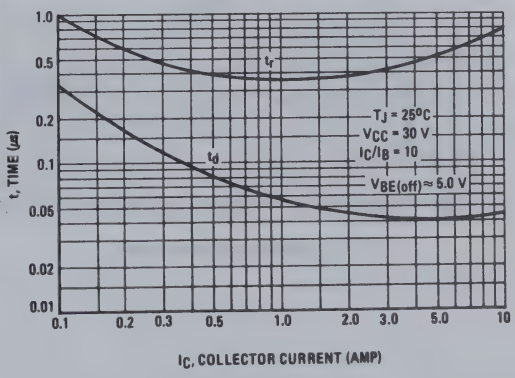


FIGURE 4 – THERMAL RESPONSE

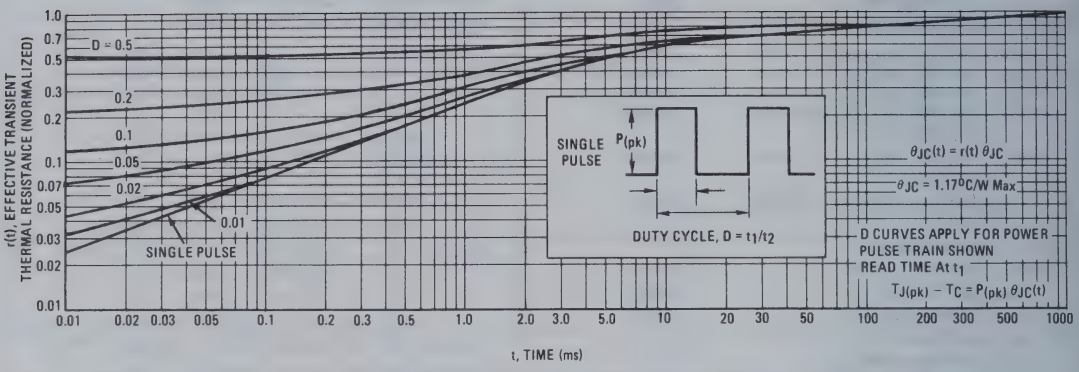
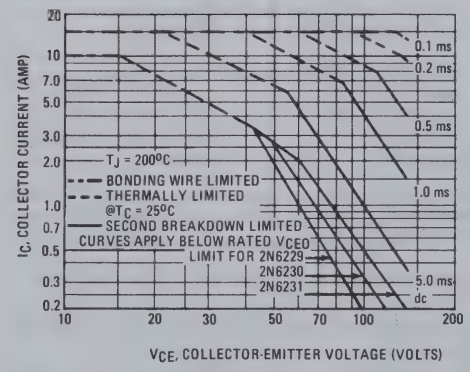


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

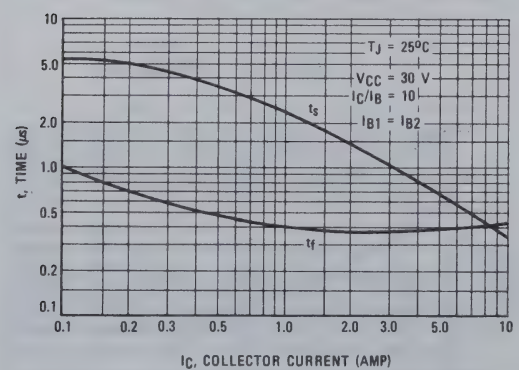


FIGURE 7 – CAPACITANCE

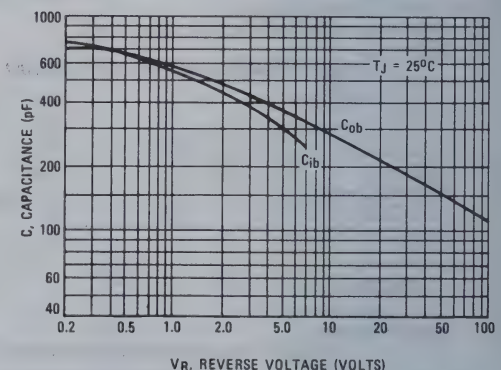


FIGURE 8 – DC CURRENT GAIN

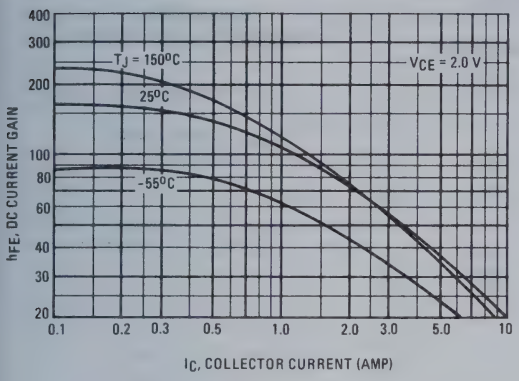


FIGURE 9 – COLLECTOR SATURATION REGION

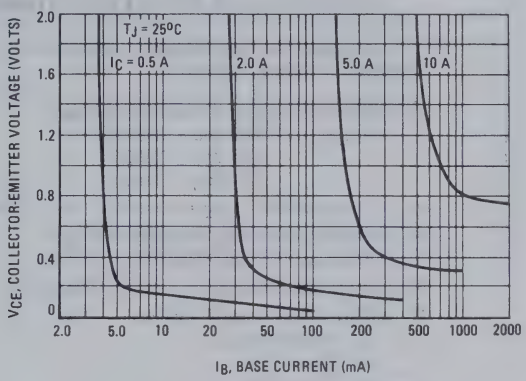


FIGURE 10 – "ON" VOLTAGES

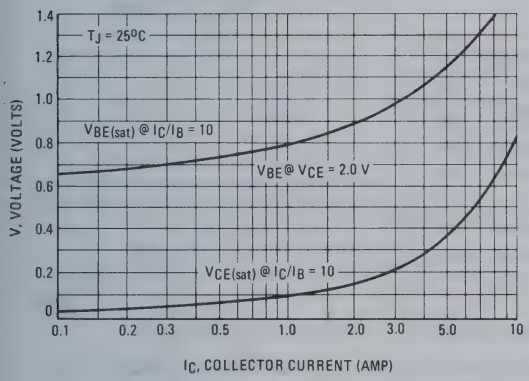


FIGURE 11 – TEMPERATURE COEFFICIENTS

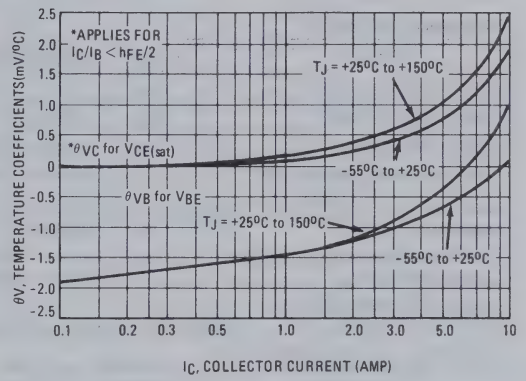


FIGURE 12 – COLLECTOR CUT-OFF REGION

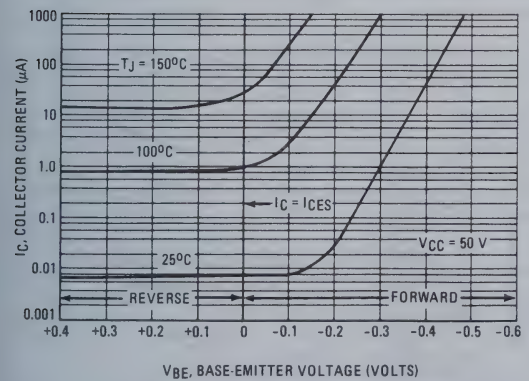
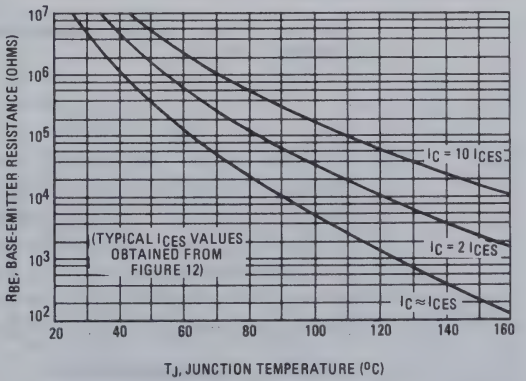


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N6233 (SILICON)
2N6234
2N6235

HIGH VOLTAGE NPN SILICON TRANSISTORS

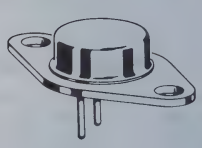
. . . designed for high reliability switching and pin diode driver applications [SAFEGUARD]

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 225 Vdc – 2N6233
  275 Vdc – 2N6234
  325 Vdc – 2N6235
- DC Current Gain – h_{FE} = 25 to 125 – I_C = 1.0 Adc
- Low Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 1.0 Adc
- High Frequency Response – f_T = 20 MHz (Min)
- Fast Switching Times @ 1.0 Adc –
  t_r = 0.5 μs (Max)
  t_s = 3.5 μs (Max)
  t_f = 0.5 μs (Max)
- Environment Test Data Available

5 AMPERE POWER TRANSISTORS

NPN SILICON

225,275,325 VOLTS
50 WATTS



*MAXIMUM RATINGS

Rating	Symbol	2N6233	2N6234	2N6235	Unit
Collector-Emitter Voltage	V_{CEO}	225	275	325	Vdc
Collector-Base Voltage	V_{CB}	250	300	350	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current – Continuous	I_C	← 5.0 →			Adc
Peak		← 10 →			
Base Current	I_B	← 2.0 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 50 →			Watts
Derate above 25°C		← 0.286 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.5	°C/W

*Indicates JEDEC Registered Data.

All JEDEC dimensions and notes apply

Collector connected to case

CASE 80-02
TO-66

FIGURE 1 – POWER TEMPERATURE DERATING

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

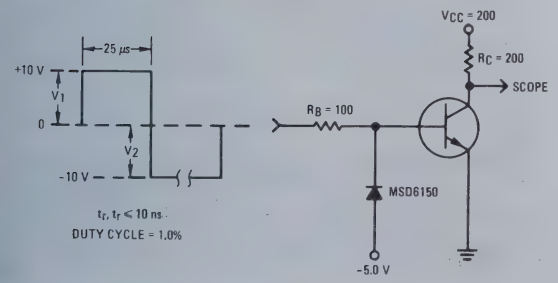
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 20 mAdc, I_B = 0)	2N6233		225	–	
	2N6234		275	–	
	2N6235		325	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 225, I_B = 0)	2N6233		–	1.0	
(V_{CE} = 275, I_B = 0)	2N6234		–	1.0	
(V_{CE} = 325, I_B = 0)	2N6235		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6233		–	1.0	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6234		–	1.0	
(V_{CE} = 350 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6235		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 250 Vdc, I_E = 0)	2N6233		–	0.1	
(V_{CB} = 300 Vdc, I_E = 0)	2N6234		–	0.1	
(V_{CB} = 350 Vdc, I_E = 0)	2N6235		–	0.1	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 6.0 Vdc, I_C = 0)			–	0.1	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 0.1 Adc, V_{CE} = 5.0 Vdc)			25	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			25	125	
(I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)			–	0.5	
(I_C = 5.0 Adc, I_B = 1.0 Adc)			–	2.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)			–	1.0	
(I_C = 5.0 Adc, I_B = 1.0 Adc)			–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain Bandwidth Product (2)		f_T			MHz
(I_C = 0.25 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)			20	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	250	
SWITCHING CHARACTERISTICS					
Rise Time		t_r			μs
(V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_B = 0.1 Adc)			–	0.5	
Storage Time		t_s			μs
(V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)			–	3.5	
Fall Time		t_f			μs
(V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)			–	0.5	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR INFORMATION ON FIGURES 3 and 6 R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS. D_1 DISCONNECTED AND V_2 REDUCED TO 5 VOLTS FOR t_d MEASUREMENT.

FIGURE 3 – TURN-ON TIME

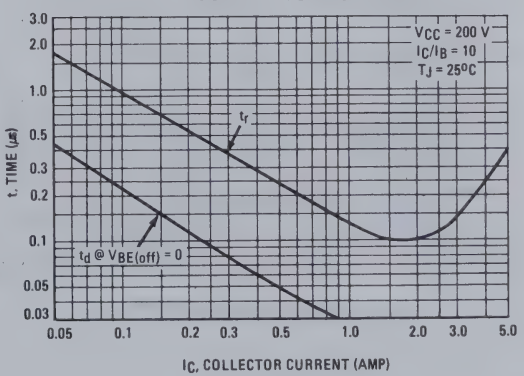


FIGURE 4 – THERMAL RESPONSE

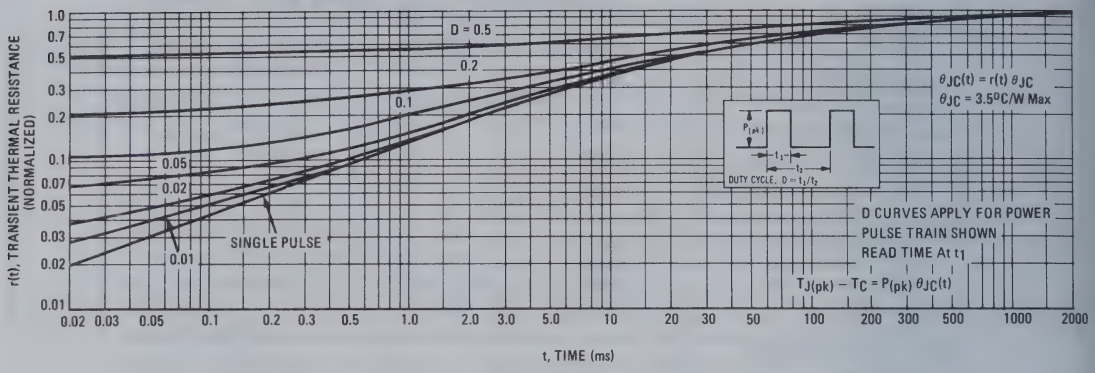
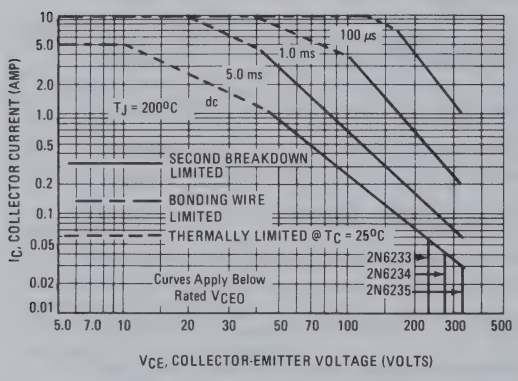


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

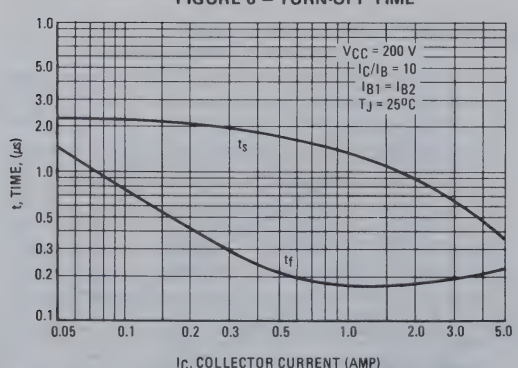


FIGURE 7 – CAPACITANCES

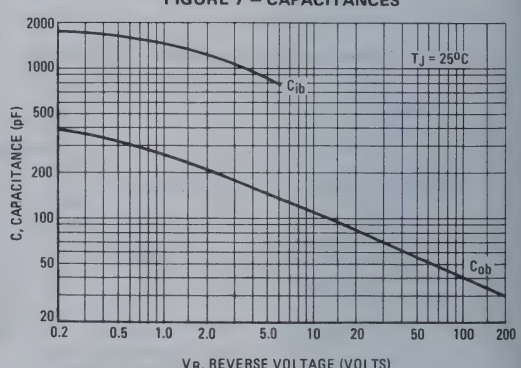


FIGURE 8 – DC CURRENT GAIN

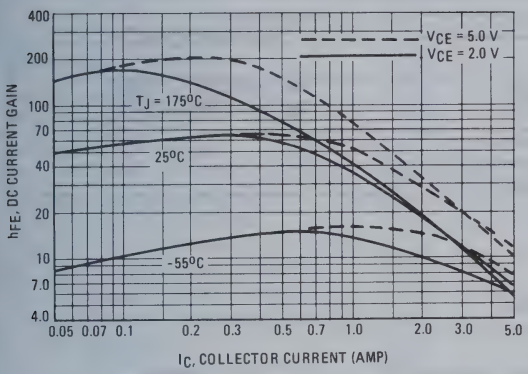


FIGURE 9 – COLLECTOR SATURATION REGION

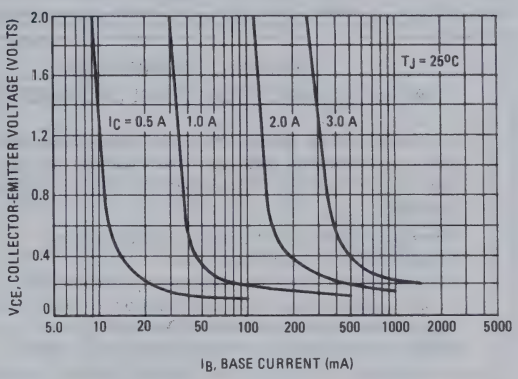


FIGURE 10 – "ON" VOLTAGES

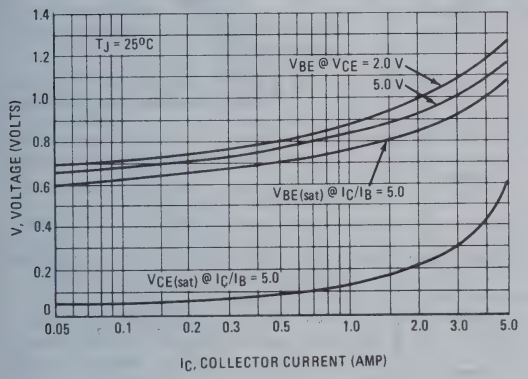


FIGURE 11 – TEMPERATURE COEFFICIENTS

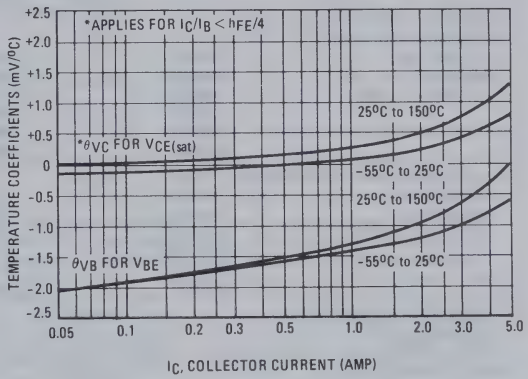


FIGURE 12 – COLLECTOR CUT-OFF REGION

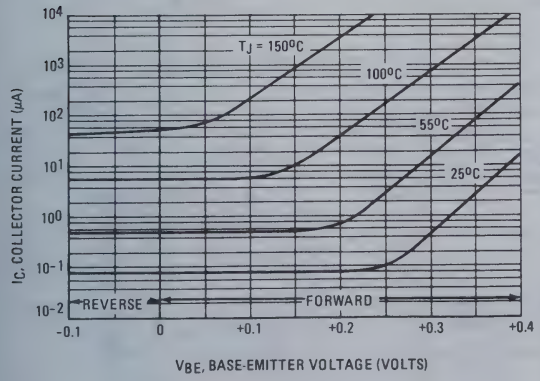
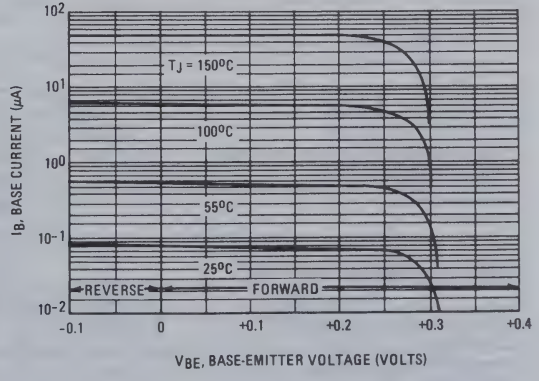


FIGURE 13 – BASE CUT-OFF REGION



2N6236 thru 2N6241 (SILICON)



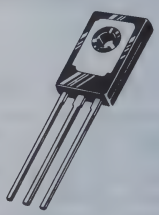
PLASTIC THYRISTORS
(PLASTIC SILICON CONTROLLED RECTIFIERS)

. . . PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Recommended Electrical Replacement for C 106

THYRISTORS

4.0 AMPERES RMS
30 thru 600 VOLTS



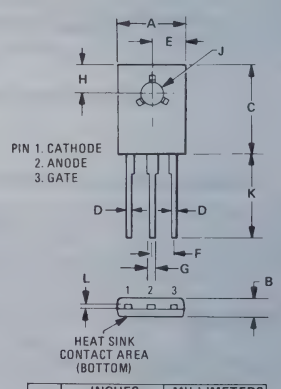
MAXIMUM RATINGS (T_J = 100°C unless otherwise noted.)

Rating		Symbol	Value	Unit
*Repetitive Peak Forward and Reverse Blocking Voltage (Note 1) (1/2 Sine Wave) (Gate Open, T_J = -40 to +110°C)	2N6236	V_{DRM}, V_{RRM}	30	Volts
	2N6237		50	
	2N6238		100	
	2N6239		200	
	2N6240		400	
	2N6241		600	
*Non-Repetitive Peak Reverse Blocking Voltage (1/2 Sine Wave, Gate Open, T_J = -40 to +110°C)	2N6236	V_{RSM}	50	Volts
	2N6237		100	
	2N6238		150	
	2N6239		250	
	2N6240		450	
	2N6241		650	
*Average On-State Current (T_C = -40 to +90°C) (T_C = +100°C)		$I_{T(AV)}$	2.6 1.6	Amp
*Surge On-State Current (1/2 Sine Wave, 60 Hz, T_C = +90°C) (1/2 Sine Wave, 1.5 ms, T_C = +90°C)		I_{TSM}	25 35	Amp
Circuit Fusing Considerations (T_J = -40 to +110°C, t = 1.0 to 8.3 ms)		I^2t	2.6	A^2s
*Peak Gate Power (Pulse Width = 10 μs)		P_{GM}	0.5	Watts
*Average Gate Power (t = 8.3 ms)		$P_{G(AV)}$	0.1	Watt
Peak Forward Gate Current		I_{GM}	0.2	Amp
Peak Reverse Gate Voltage		V_{RGM}	6.0	Volts
*Operating Junction Temperature Range		T_J	-40 to +110	°C
*Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Torque (Note 2)		—	6.0	in.lb

THERMAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	—	3.0	°C/W
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	—	75	°C/W

*Indicates JEDEC Registered Data.



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.270	0.330	6.860	8.380
B	0.070	0.130	1.770	3.300
C	0.390	0.450	9.910	11.430
D	0.020	0.026	0.508	0.660
E	0.150 NOM		3.810 NOM	
F	0.090 TP		2.290 TP	
G	0.025	0.035	0.635	0.889
H	0.130	0.175	3.300	4.450
J	0.115	0.118	2.910	3.000
K	0.595	0.655	15.110	16.650
L	0.015	0.025	0.381	0.635

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms.)

Characteristics	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Current (Note 1) (Rated V_{DRM}, T_J = 110°C)	I_{DRM}	–	–	200	μA
*Peak Reverse Blocking Current (Note 1) (Rated V_{RRM}, T_J = 110°C)	I_{RRM}	–	–	200	μA
*Peak Forward "On" Voltage (I_{TM} = 8.2 A Peak, Pulse Width = 1 to 2 ms, 2% Duty Cycle)	V_{TM}	–	–	2.2	Volts
Gate Trigger Current (Continuous dc) (V_{AK} = 12 Vdc, R_L = 24 Ohms) *(V_{AK} = 12 Vdc, R_L = 24 Ohms, T_C = -40°C)	I_{GT}	– –	– –	200 500	μA
Gate Trigger Voltage (Continuous dc) (Source Voltage = 12 V, R_S = 50 Ohms) *(V_{AK} = 12 Vdc, R_L = 24 Ohms, T_C = -40°C)	V_{GT}	–	–	1.0	Volts
Gate Non-Trigger Voltage (V_{AK} = Rated V_{DRM}, R_L = 100 Ohms, T_J = 110°C)	V_{GD}	0.2	–	–	Volts
Holding Current (V_{AK} = 12 Vdc, I_{GT} = 2.0 mA) T_J = 25°C *(Initiating On-State Current = 200 mA) T_J = -40°C	I_H	– –	– –	5.0 10	mA
*Total Turn-On Time (Source Voltage = 12 V, R_S = 6.0 k Ohms) (I_{TM} = 8.2 A, I_{GT} = 2.0 mA, Rated V_{DRM}) (Rise Time = 20 ns, Pulse Width = 10 μs)	t_{gt}	–	–	2.0	μs
Forward Voltage Application Rate (T_J = 110°C)	dv/dt	–	10	–	V/μs

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common. (See AN-290 B)

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

CURRENT DERATING

FIGURE 1 – MAXIMUM CASE TEMPERATURE

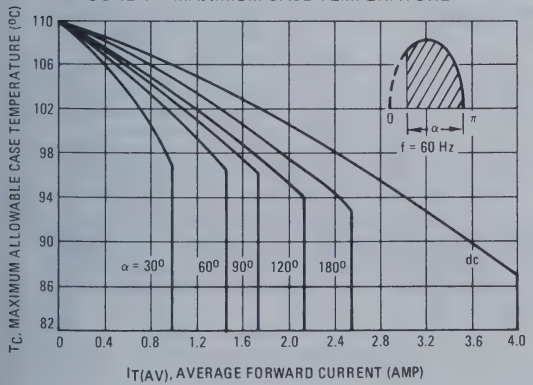
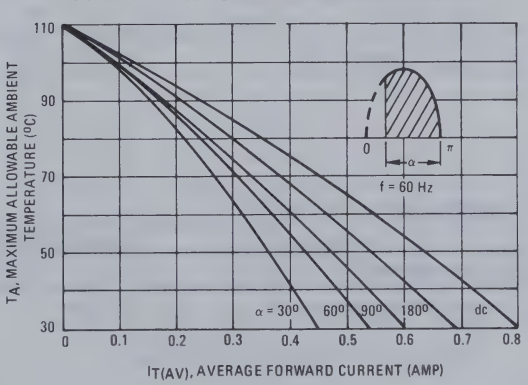


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



2N6253, 2N6254 (SILICON)

NPN SILICON POWER TRANSISTORS

Unibase▲ (single-diffused) transistors designed for use in untuned amplifier applications; series pass and switching regulator circuitry, control circuitry where highly inductive loads are employed.

. . . 2N6254 – Premium Version of the 2N3055 Transistor

- $V_{CEO(sus)}$ = 80 Vdc (Min)
- h_{FE} = 20-70 @ I_C = 5.0 Adc
- $I_{S/b}$ = 1.9 Adc @ V_{CE} = 80 Vdc, t = 1.0 s

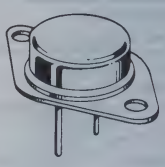
. . . 2N6253 – High-Yield Version of 2N3055 Transistor

- $V_{CEO(sus)}$ = 45 Vdc (Min)
- h_{FE} = 20-150 @ I_C = 3.0 Adc
- $I_{S/b}$ = 2.6 Adc @ V_{CE} = 45 Vdc, t = 1.0 s

15 AMPERE

POWER TRANSISTORS NPN SILICON

45 and 80 VOLTS
115 and 150 WATTS



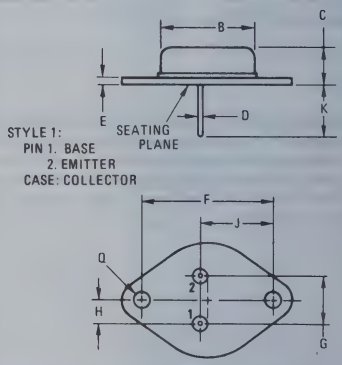
MAXIMUM RATINGS

Rating	Symbol	2N6253	2N6254	Unit
*Collector-Emitter Voltage	V_{CEO}	45	80	Vdc
*Collector-Base Voltage	V_{CB}	55	100	Vdc
Collector-Emitter Voltage	V_{CEX}	55	90	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	55	85	Vdc
*Emitter-Base Voltage	V_{EB}	5.0	7.0	Vdc
*Collector Current – Continuous	I_C	15		Adc
*Base Current	I_B	7.0		Adc
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.657	150 0.857	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200°C		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N6253	2N6254	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.52	1.17	°C/W

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0.188

All JEDEC dimensions and notes apply

CASE 1 TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	2N6253		45	–	
	2N6254		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 25 Vdc, I_B = 0)	2N6253		–	1.5	
(V_{CE} = 60 Vdc, I_B = 0)	2N6254		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 55 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6253		–	2.0	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6254		–	0.5	
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6253		–	10	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6254		–	5.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)	2N6253		–	10	
(V_{BE} = 7.0 Vdc, I_C = 0)	2N6254		–	0.5	
ON CHARACTERISTICS					
*DC Current Gain (1)		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	2N6253		20	150	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N6254		20	70	
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)	2N6253		3.0	–	
	2N6254		5.0	–	
*Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 15 Adc, I_B = 5.0 Adc)	2N6253		–	4.0	
(I_C = 15 Adc, I_B = 3.0 Adc)	2N6254		–	4.0	
*Base-Emitter On Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	2N6253		–	1.7	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N6254		–	1.5	
Second Breakdown Collector Current with Base Forward Biased (t = 1.0 s)		$I_{S/b}$			Adc
(V_{CE} = 45 Vdc)	2N6253		2.6	–	
(V_{CE} = 80 Vdc)	2N6254		1.9	–	
DYNAMIC CHARACTERISTICS					
Magnitude of Common-Emitter Small-Signal, Short Circuit Current Transfer Ratio (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 0.4 MHz)		$\lvert h_{fe} \rvert$	2.0	–	–
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	10	–	–
Common-Emitter, Short Circuit, Small-Signal Forward Current Transfer Ratio Cutoff Frequency (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		f_{hfe}	10	–	kHz

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR CUTOFF REGION

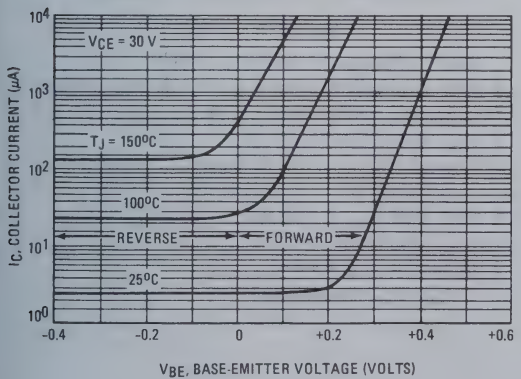
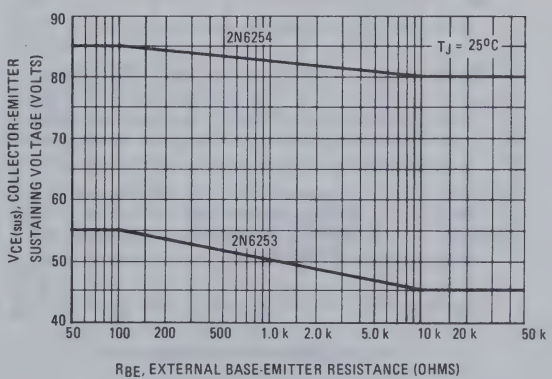


FIGURE 2 – SUSTAINING VOLTAGE



ACTIVE-REGION SAFE-OPERATING AREA INFORMATION

FIGURE 3 – POWER DERATING

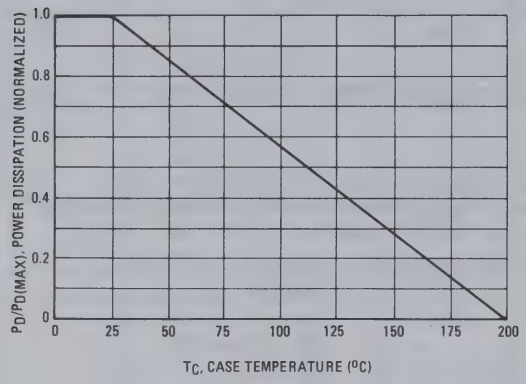


FIGURE 4 – 2N6253

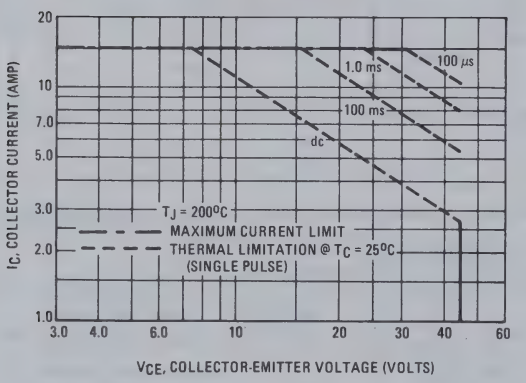
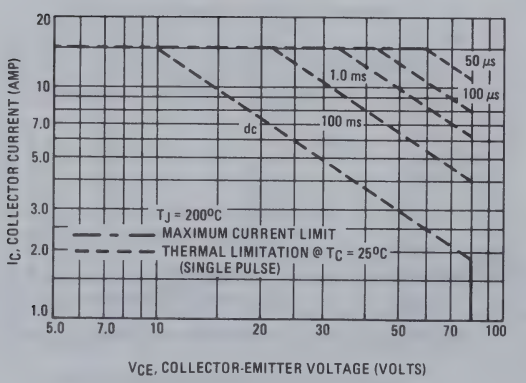


FIGURE 5 – 2N6254



SAFE-OPERATING AREA NOTE

Safe operating area curves, Figure 4 and Figure 5, indicate V_{CE}-I_C limits that must be observed for reliable operation. These curves, in conjunction with the power derating curve shown in Figure 3 define the maximum power handling ability of the transistor(s) in the active region.

Power must be linearly derated to zero at T_C = 200°C. For d.c. conditions and single pulse operation, the value(s) from the curves of Figure 4 or Figure 5 are derated using Figure 3. For repetitive pulse operation, an "effective case temperature" ($T_{C(eff)}$) must be determined and used with the normalized curve of Figure 3.

The iterative procedure for determination of peak power (or peak current at a given voltage) and $T_{C(eff)}$ is outlined below:

Example: Determine max. current allowed for 2N6254 when V_{CE} = 30 V, Pulse Width (t_w) = 100 ms, Duty Cycle (D) = 10% and Case Temperature (T_C) = 100°C.

PROCEDURE

1. Find $[P_D/P_{D(max)}]$ @ T_C from Figure 3.
2. Find $I_{C(25°C)}$ @ V_{CE} and t_w from Figure 4 or 5.
3. Calculate max. current for a single pulse:
   $I_{C(T)_1} = [P_D/P_{D(max)}] \times I_{C(25°C)}$
4. Estimate maximum current for a repetitive pulse by multiplying $I_{C(T)_1}$ by the factor (1-D)
   $I_{Cp} = I_{C(T)_1} \times (1\text{-}D)$
5. Calculate effective case temperature;
   $T_{C(eff)} = T_C + P_{PK}\ (D)\ (R_{\theta JC})$
   Where:
   $P_{PK} = I_{Cp} \times V_{CE}$
6. Find $[P_D/P_{D(max)}]'$ @ $T_{C(eff)}$ from Figure 3.
7. Calculate I_{Cp}' as $I_{Cp}' = I_{C(25°C)} \times P_D/P_{D(max)}'$
8. Compare I_{Cp} found in step 4 with I_{Cp}' from step 7. If the calculated values are within 10% of each other, use the lower value. If the values differ by more than 10%, adjust I_C (from step 3) down if $I_{Cp} > I_{Cp}'$, up if $I_{Cp} < I_{Cp}'$ by 10% and repeat steps 4 through 8.

EXAMPLE VALUES

1. Read $[P_D/P_{D(max)}] = 0.56$ @ T_C = 100°C
2. Read $I_{C(25°C)} = 10.2$ A @ V_{CE} = 30 V and t_w = 100 ms.
3. $I_{C(100°C)_1} = (0.56)\ (10.2) = 5.7$ A
4. $I_{Cp} = (5.7) \times (1.0\text{-}.1) \approx 5.1$ A
5. $T_{C(eff)} = 100 + (5.1)\ (30)\ (0.1)\ (1.17)$
   $\approx 118°C$
6. Read $[P_D/P_{D(max)}]' \approx 0.46$
7. $I_{Cp}' = (10.2)\ (0.46) \approx 4.7$ A
8. $I_{Cp} \approx 5.1$ A, $I_{Cp}' \approx 4.7$ A
   $I_{Cp} \approx I_{Cp}'$ (Close enough)

FIGURE 6 – DC CURRENT GAIN

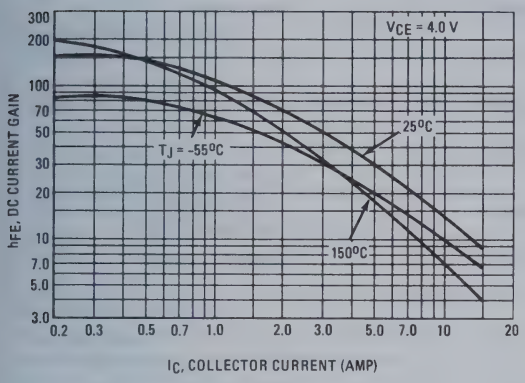


FIGURE 7 – COLLECTOR SATURATION REGION

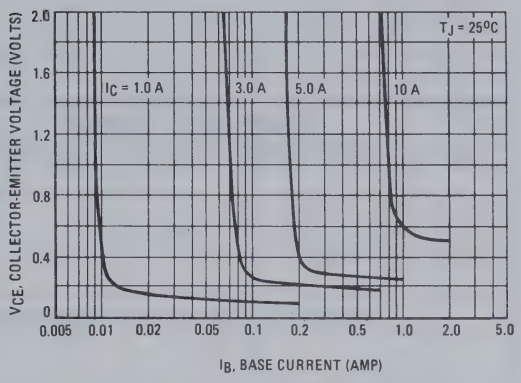


FIGURE 8 – "ON" VOLTAGE

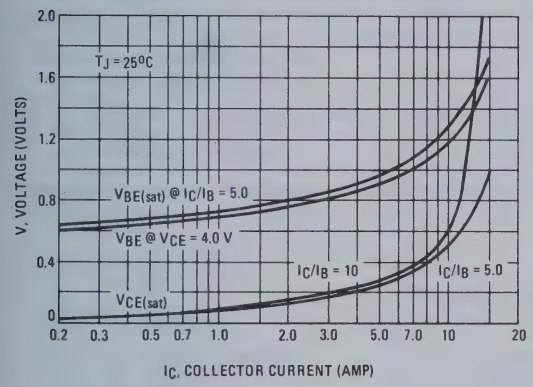
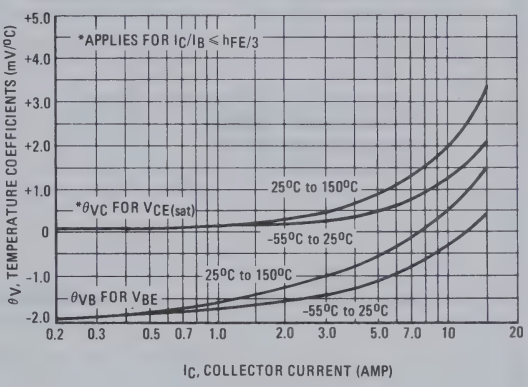


FIGURE 9 – TEMPERATURE COEFFICIENTS



2N6255 (SILICON)

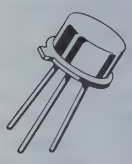
The RF Line

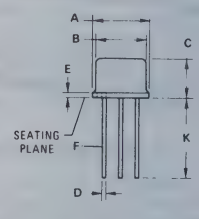
NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt VHF large-signal amplifier applications required in industrial and commercial FM equipment.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 3.0 Watts
  Minimum Gain = 7.8 dB
  Efficiency = 50%

3.0 W-175 MHz
RF POWER
TRANSISTOR
NPN SILICON





Pin 1. Emitter
2. Base
3. Collector

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	5.0	Watts
Derate above 25^oC		28.5	$mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.

This device is designed for RF operation. The total device dissipation applies only when the device is operated as an RF amplifier.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.016	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45^o NOM		45^o NOM	
N	90^o NOM		90^o NOM	

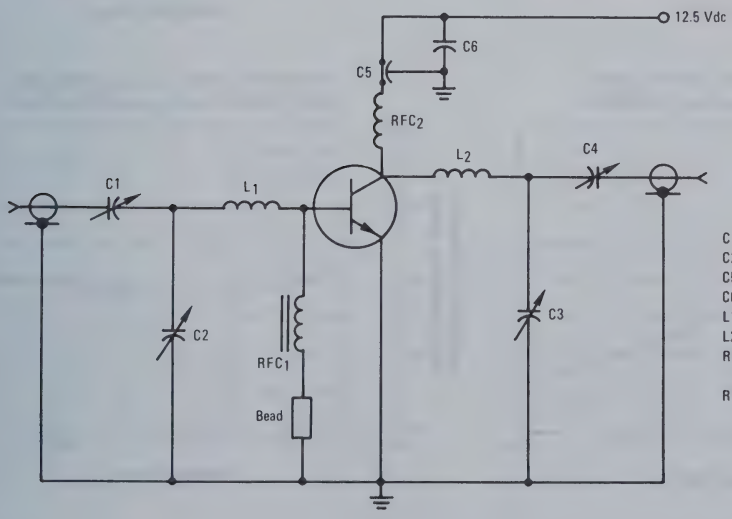
All JEDEC dimensions and notes apply

Collector connected to case.
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.25	mAdc
ON CHARACTERISTICS					
Dc Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	15	20	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	7.8	–	–	dB
Collector Efficiency (P_{out} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz CIRCUIT



C1,3	2.0-50 pF ARCO 461 ELMENCO
C2,4	5.0-80 pF ARCO 462 ELMENCO
C5	1000 pF FEED THRU
C6	5.0 μF
L1	1 TURN #18 AWG ¼" I.D.
L2	2½ TURNS #18 AWG ¼" I.D.
RFC1	0.15 μH MOLDED CHOKE WITH BEAD ON GROUND LEG
RFC2	0.15 μH MOLDED CHOKE

BEAD IS FERROXCUBE 56-570-65/3B

FIGURE 2 – OUTPUT POWER versus INPUT POWER

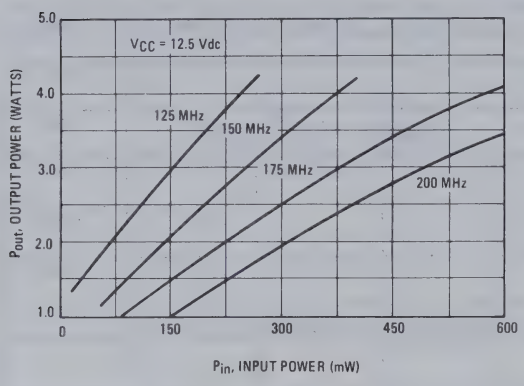


FIGURE 3 – OUTPUT POWER versus SUPPLY VOLTAGE

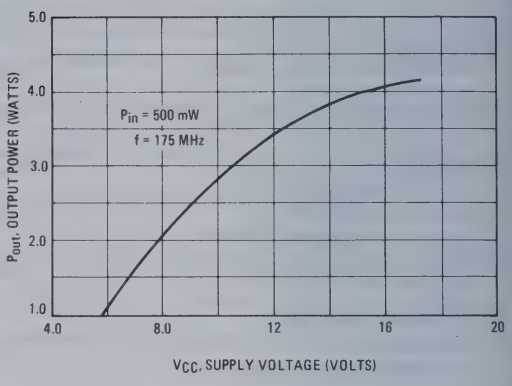


FIGURE 4 – COLLECTOR LOAD versus FREQUENCY

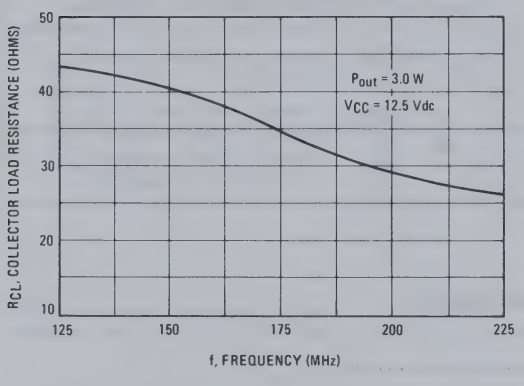


FIGURE 5 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

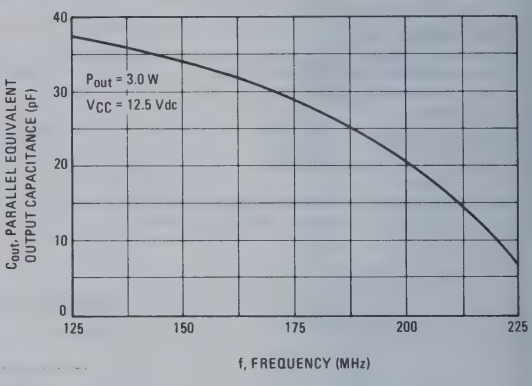


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

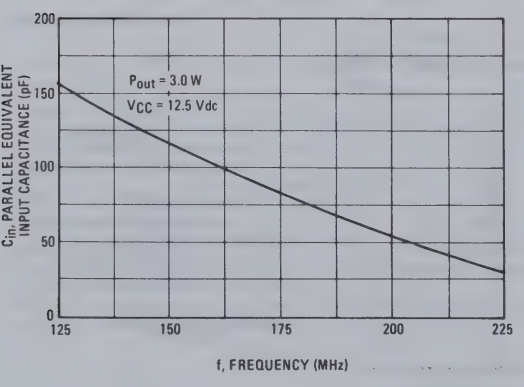
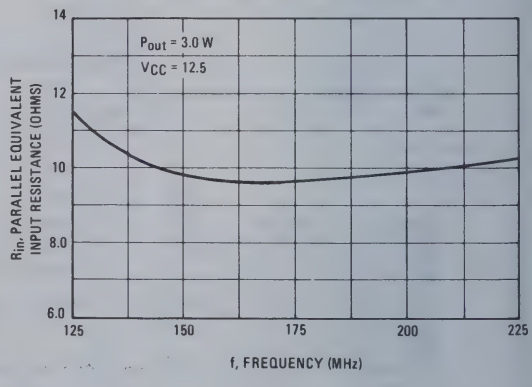
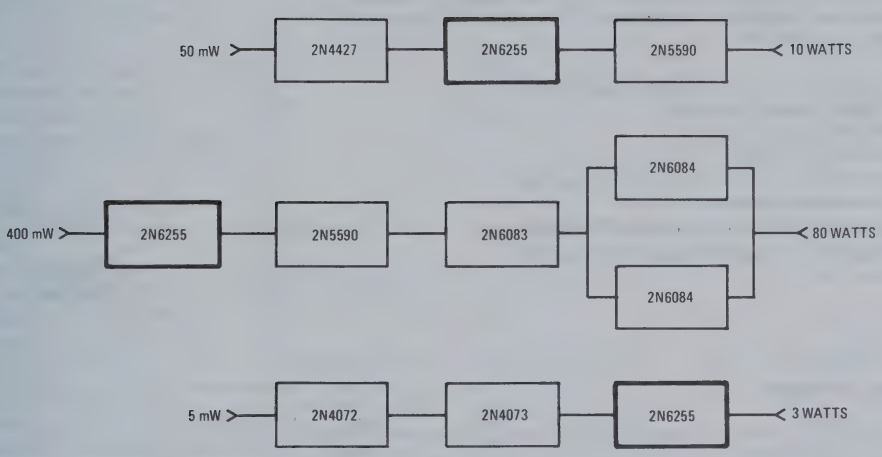


FIGURE 7 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY



175 MHz AMPLIFIER BLOCK DIAGRAMS

FIGURE 8 – V_{CC} = 12.5 VOLTS



2N6256 (SILICON)

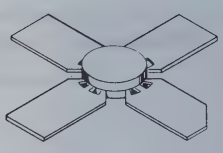
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, VHF/UHF large signal Amplifier/Multiplier applications required in industrial and commercial FM equipment operating to 520 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics
  Power Output = 0.5 Watts
  Minimum Gain = 7.0 dB
  Efficiency = 60%
- Characterized with series equivalent large signal impedance parameters
- Driver for 2N5944 and 2N5945 UHF amplifiers
- Capable of withstanding severe load mismatch

0.5 WATT – 470 MHz RF POWER TRANSISTOR NPN SILICON

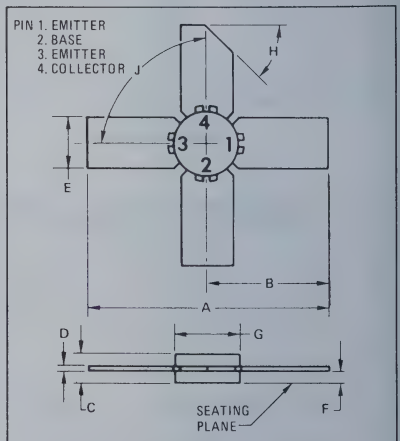


***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Continuous Device Dissipation @ $T_C = 25^oC$ – Derate above 25^oC	P_D	2.0 11.4	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

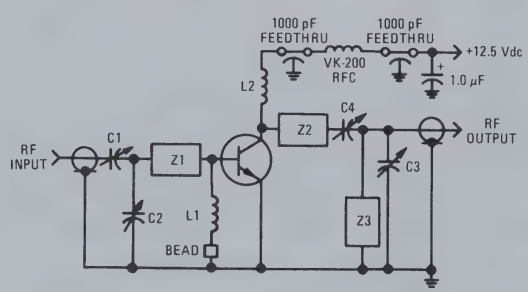
* Indicates JEDEC Registered Data



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.055	1.065	26.800	27.050
B	0.525	0.535	13.340	13.600
C	0.115	0.132	2.920	3.350
D	0.004	0.006	0.102	0.152
E	0.220	0.230	5.590	5.840
F	0.055	0.065	1.400	1.650
G	0.278	0.286	7.060	7.260
H	40^0	50^0	40^0	50^0
J	90^0 TP		90^0 TP	

CASE 249-01

FIGURE 1 – 470 MHz TEST CIRCUIT SCHEMATIC



NOTE: Test Circuit Layout and Component Descriptions Shown in Figure 6.

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	–	–	5.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
Dc Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	80	200	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	6.0	8.0	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figures 1, 6) (P_{out} = 0.5 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	G_{PE}	7.0	9.0	–	dB
Collector Efficiency (Figures 1, 6) (P_{out} = 0.5 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	η	60	70	–	%

*Indicates JEDEC Registered Data.

Typical Output Power curves were measured in circuit shown in Figure 6.

FIGURE 2 – OUTPUT POWER versus FREQUENCY

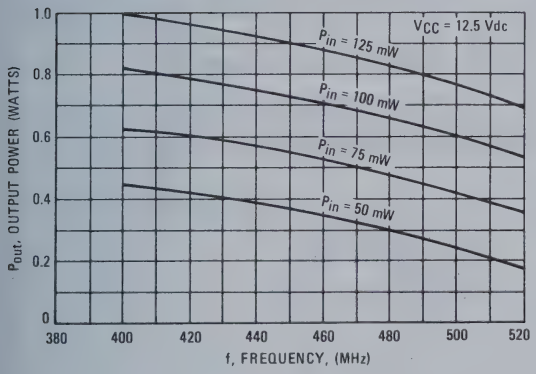


FIGURE 3 – OUTPUT POWER versus INPUT POWER

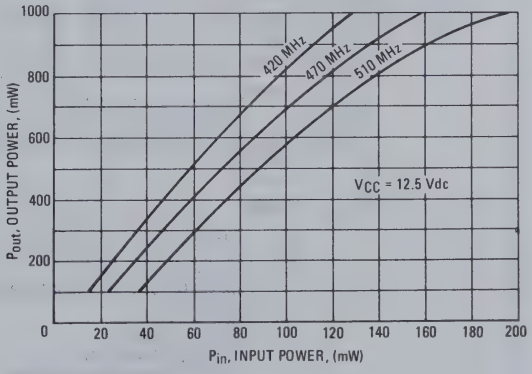


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE (f = 470 MHz)

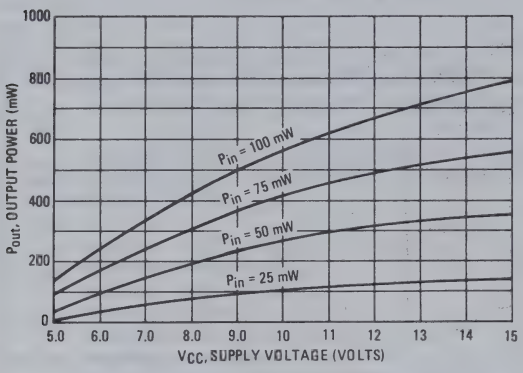


FIGURE 5 – SERIES EQUIVALENT INPUT and OUTPUT IMPEDANCE (V_{CC} = 12.5 Vdc, P_{out} = 0.5 Watts)

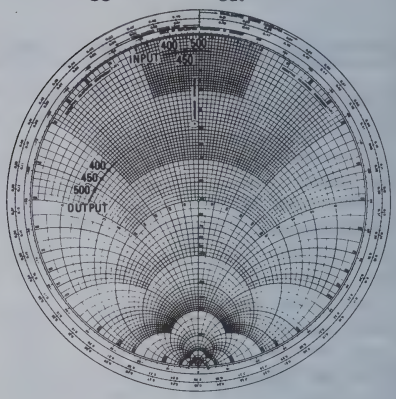
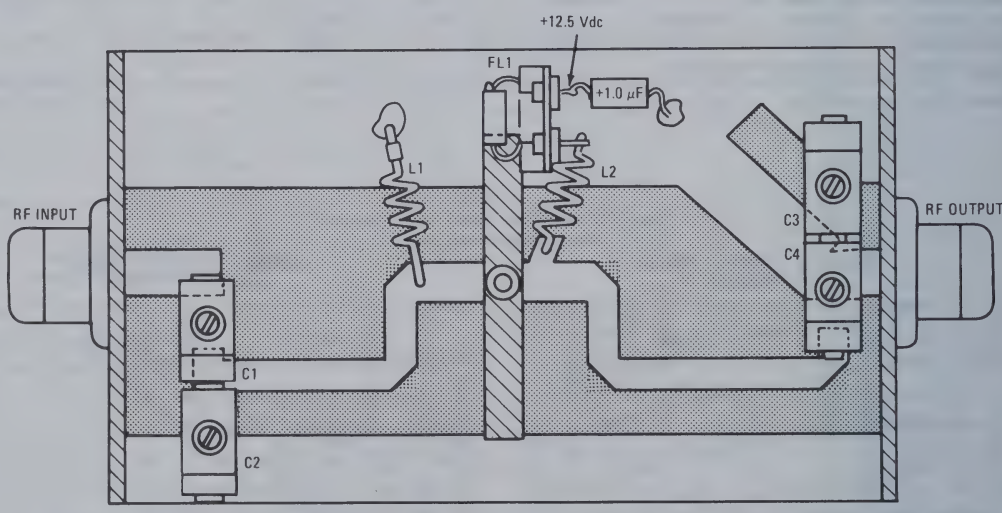


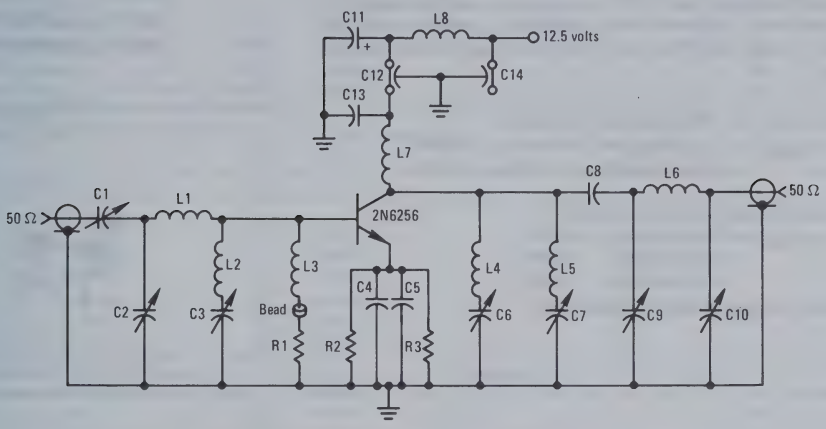
FIGURE 6 – 470 MHz TEST CIRCUIT LAYOUT (See Figure 1 for Schematic Diagram)



C1,2 1.0-25 pF ARCO 421 OR EQUIVALENT
C3,4 1.0-25 pF ARCO 421 OR EQUIVALENT
L1,2 7 TURNS #22 AWG, 0.2" I.D.
FERRITE BEAD FERROXCUBE 56-590-65-3B
AS SHOWN ON L1
FL1 DC SUPPLY FILTER
2-1000 pF FT CAPACITOR
1-1.0 μF, 35 V CAPACITOR
1-CHOKE FERROXCUBE VK 200-20-4B

CONNECTORS ARE TYPE "N"
BOARD IS GLASS TEFLON
3" x 5" x 0.060"
MOUNTING PLATE IS 3" x 5" x 0.75"

FIGURE 7 – 150 MHz to 450 MHz TRIPLER USING 2N6256



C1, 2, 3, 9, 10 1-7 pF ARCO 400 OR EQUIVALENT
C6, 7 1.5-20 pF ARCO 402 OR EQUIVALENT
C4, 5 470 pF ATC TYPE 100-B-420-m-ms
C8 1000 pF UNDERWOOD TYPE J-101
C11 0.47 μF TANTALUM
C12, 14 470 pF FEED THRU
C13 0.1 μF CERAMIC
R1-20 OHM
R2,3-160 OHM

L1 7 TURNS 1/4" I.D.
L2,6-4 TURNS 1/8" I.D.
L3 0.68 μH MOLDED CHOKE
L4 5 TURNS 1/4" I.D.
L5 6 TURNS 1/8" I.D.
L7 1 μH MOLDED CHOKE
L8 FERROXCUBE VK200-20/4B
FERRITE BEAD IS FERROXCUBE 56-590-65/3B

NOTE: ALL COILS AIR CORE SPACE WOUND WITH #20 AWG WIRE UNLESS OTHERWISE SPECIFIED

Figure 7 shows the 2N6256 in a 150 MHz to 450 MHz tripler circuit. This circuit will typically produce 85 mW at 450 MHz with 30 mW at 150 MHz input (4.5 db gain). Collector efficiency is 25% and all unwanted harmonics are at least 30 db down from the 450 MHz output level.

It is important that each emitter lead be bypassed separately with a good hi-quality capacitor. The emitter resistor is likewise split in two with one-half on each emitter lead.

The input network is a modified "TEE" consisting of C1, C2, and L1, which matches the 50 Ohm input to the transistor impedance at 150 MHz; this is roughly 18-j20 Ohms. The combination of L2 and C3 form a 450 MHz idler to provide a base return for third harmonic current. L4, C6 and L5, C7 are 150 MHz and 300 MHz output idlers respectively. The output matching section is a pi network made up of L6, C9 and C10. All coils are air core space-wound (turns one wire diameter apart) with #20 AWG wire.

2N6262 (SILICON)

2N4347

2N3442

RUGGED HIGH POWER INDUSTRIAL TRANSISTORS

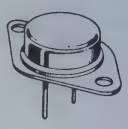
Unibase▲ (single-diffused) NPN silicon power transistors designed for applications in industrial and commercial equipment including high fidelity audio amplifiers, series and shunt regulators and power switches.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 2.0 Adc — 2N4347
  0.5 Vdc (Max) @ I_C = 3.0 Adc — 2N6262
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 120 Vdc (Min) — 2N4347
  140 Vdc (Min) — 2N3442
  150 Vdc (Min) — 2N6262
- Excellent Second-Breakdown Capability

5.0 AND 10 AMPERE POWER TRANSISTORS

NPN SILICON

120, 140, 150 VOLTS
100, 117, 150 WATTS



*MAXIMUM RATINGS

Rating	Symbol	2N4347	2N3442	2N6262	Unit
Collector-Emitter Voltage	V_{CEO}	120	140	150	Vdc
Collector-Base Voltage	V_{CB}	140	160	170	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous Peak	I_C	5.0 10	10 15**	10 15**	Adc
Base Current — Continuous Peak	I_B	3.0 8.0	7.0 —	7.0 —	Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.57	117 0.67	150 0.857	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← −65 to +200 →			°C

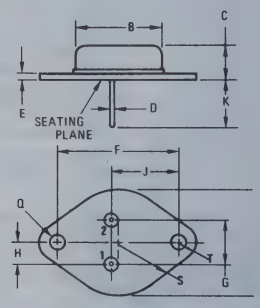
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N4347	2N3442	2N6262	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	1.50	1.17	°C/W

*Indicates JEDEC Registered Data.

**This data guaranteed in addition to JEDEC registered data.

▲Trademark of Motorola Inc.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	—	22.23	—	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	—	0.312	—
Q	3.84	4.09	0.151	0.161
S	—	13.34	—	0.525
T	—	4.78	—	0.188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

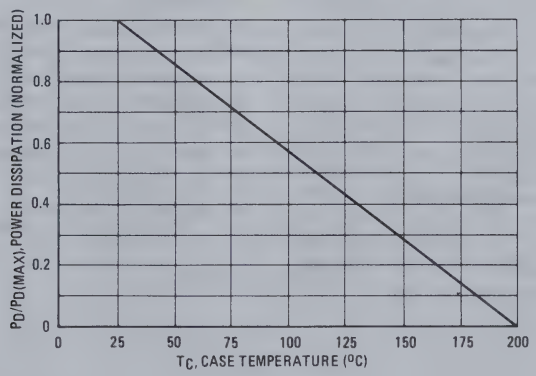
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage					
(I_C = 200 mAdc, I_B = 0)	2N4347	$V_{CEO(sus)}$	120	–	Vdc
	2N3442		140	–	
	2N6262		150	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 100 Vdc, I_B = 0)	2N4327		–	200	
(V_{CE} = 110 Vdc, I_B = 0)	2N6262		–	1.0	
(V_{CE} = 140 Vdc, I_B = 0)	2N3442		–	200	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 125 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4347		–	2.0	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3442		–	5.0	
(V_{CE} = 150 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N6262		–	0.1	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4347		–	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3442		–	30	
(V_{CE} = 150 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6262		–	2.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)	2N4347,2N3442		–	5.0	
	2N6262		–	0.2	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 4.0 Vdc)	2N4347		15	60	
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)	2N4347		10	–	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	2N3442		20	70	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N3442		7.5	–	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N6262		20	70	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N6262		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)	2N4347		–	1.0	
(I_C = 10 Adc, I_B = 2.0 Adc)	2N3442		–	5.0	
(I_C = 3.0 Adc, I_B = 300 mAdc)	2N6262		–	0.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.0 Adc, V_{CE} = 4.0 Vdc)	2N4347		–	2.0	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N3442		–	5.7	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N6262		–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T			kHz
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc, f_{test} = 50 kHz)	2N4347		200	–	
(I_C = 2.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 40 kHz)	2N3442		800	–	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 40 kHz)	2N6262		800	–	
Small-Signal Current Gain		h_{fe}			–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	2N4347		40	–	
(I_C = 2.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	2N3442		12	72	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	2N6262		10	–	

*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 1 – POWER DERATING



ACTIVE-REGION SAFE OPERATING AREA INFORMATION

FIGURE 2 – 2N6262

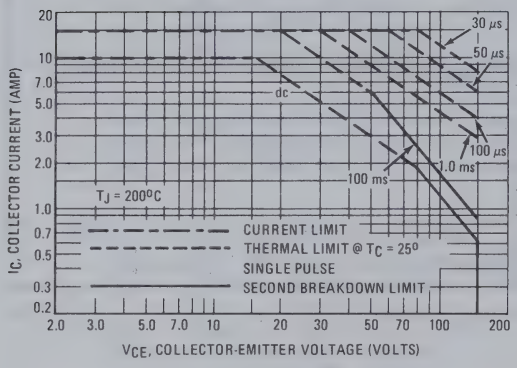


FIGURE 3 – 2N3442

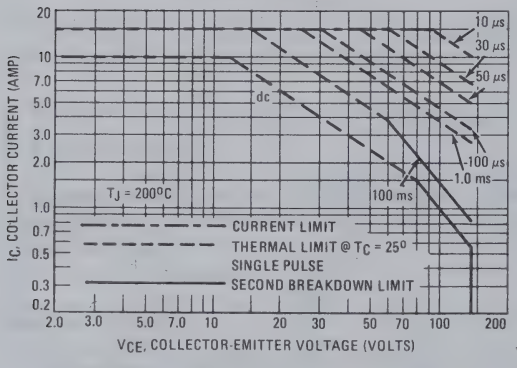
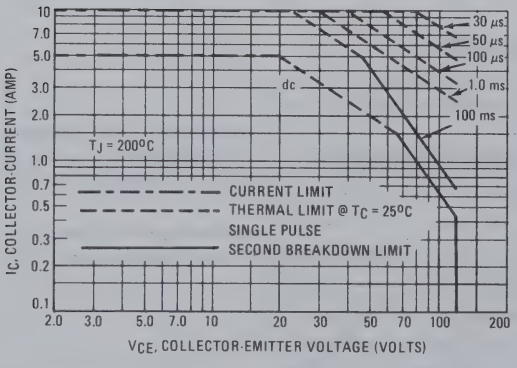


FIGURE 4 – 2N4347



Safe operating area curves, Figures 2 thru 4, indicate V_{CE}-I_C limits that must be observed for reliable operation. These curves, in conjunction with the power derating curve shown in Figure 1 define the maximum power handling ability of the transistor(s) in the active region.

Power must be linearly derated to zero at $T_C = 200^oC$. For d.c. conditions and single pulse operation, the value(s) from the curves of Figure 2, Figure 3 or Figure 4 are derated using Figure 1. For repetitive pulse operation, an "effective case temperature" ($T_{C(eff)}$) must be determined and used with the normalized curve of Figure 1.

The iterative procedure for determination of peak power (or peak current at a given voltage) and $T_{C(eff)}$ is outlined below:

PROCEDURE

1. Find $[P_D/P_{D(max)}]$ @ T_C from Figure 1.
2. Find I_C (25°C) @ V_{CE} and t_w from Figures 2, 3 or 4.
3. Calculate max current for a single pulse:
   $I_{C(T)_1} = [P_D/P_{D(max)}] \times I_C$ (25°C)
4. Estimate maximum current for a repetitive pulse by multiplying $I_{C(T)_1}$ by the factor (1-D)
   $I_{Cp} = I_C (T)_1 \times (1\text{-}D)$
5. Calculate effective case temperature;
   $T_{C(eff)} = T_C + P_{PK}$ (D) ($R_{\theta JC}$)
   Where:
   $P_{PK} = I_{Cp} \times V_{CE}$
6. Find $[P_D/P_{D(max)}]'$ @ $T_{C(eff)}$ from Figure 1.
7. Calculate I_{Cp}' as $I_{Cp}' = I_C$ (25°C) x $P_D/P_{D(max)}'$
8. Compare I_{Cp} found in step 4 with I_{Cp}' from step 7. If the calculated values are within 10% of each other, use the lower value. If the values differ by more than 10%, adjust I_C (from step 3) down if $I_{Cp} > I_{Cp}'$, up if $I_{Cp} < I_{Cp}'$ by 10% and repeat steps 4 through 8.

EXAMPLE

Determine max current allowed for 2N6262 when V_{CE} = 30 V, Pulse Width (t_w) = 100 ms, Duty Cycle (D) = 10% and Case Temperature (T_C) = 100°C.

1. Read $P_D/P_{D(max)} = 0.57$ @ $T_C = 100^oC$
2. Read I_C (25°C) = 10 A @ V_{CE} = 30 V and t_w = 100 ms
3. $I_{C(100^oC)_1} = (0.57)\ (10) = 5.7$ A
4. $I_{Cp} = (5.7) \times (1.0\text{-}.1) \approx 5.1$ A
5. $T_{C(eff)} = 100 + (5.1)\ (30)\ (0.1)\ (1.17) \approx 118^oC$
6. Read $[P_D/P_{D(max)}]' \approx 0.48$
7. $I_{Cp}' = (10)\ (0.48) \approx 4.8$ A
8. $I_{Cp} \approx 5.1$ A, $I_{Cp}' \approx 4.8$ A
   $I_{Cp} \approx I_{Cp}'$ (Close enough)

FIGURE 5 – DC CURRENT GAIN

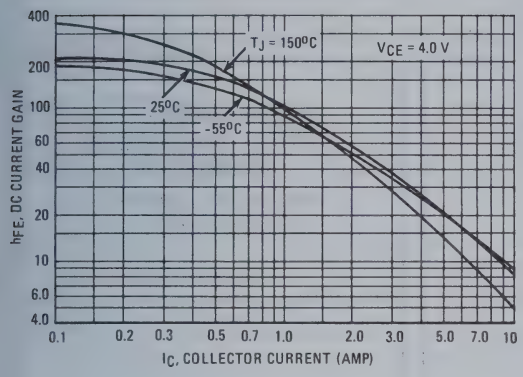


FIGURE 6 – COLLECTOR SATURATION REGION

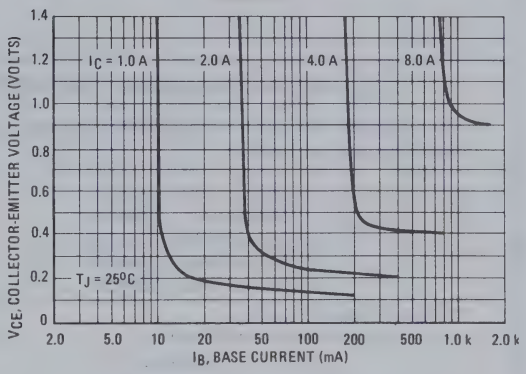


FIGURE 7 – "ON" VOLTAGE

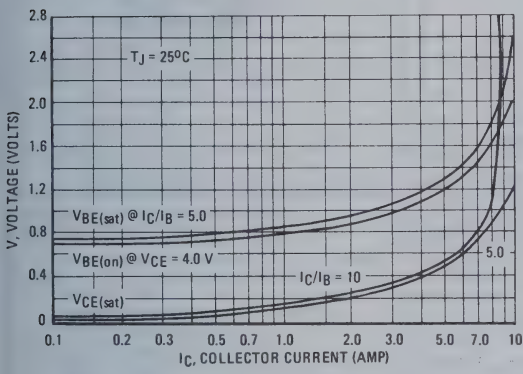


FIGURE 8 – COLLECTOR CUTOFF REGION

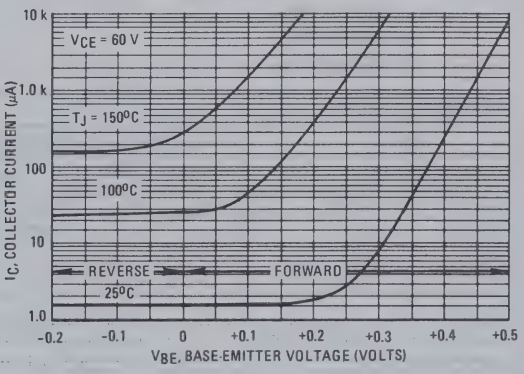
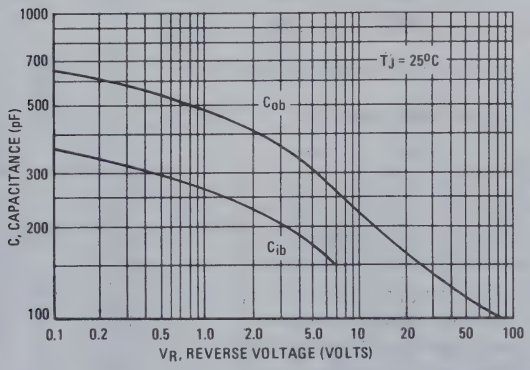


FIGURE 9 – CAPACITANCE



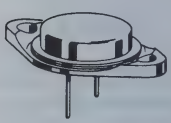
2N6274 (SILICON)
thru
2N6277

HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifer and switching circuit applications.

- High Collector Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) – 2N6274
  = 120 Vdc (Min) – 2N6275
  = 140 Vdc (Min) – 2N6276
  = 150 Vdc (Min) – 2N6277
- High DC Current Gain –
  h_{FE} = 30-120 @ I_C = 20 Adc
  = 10 (Min) @ I_C = 50 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 20 Adc
- Fast Switching Times @ I_C = 20 Adc
  t_r = 0.35 μs (Max)
  t_s = 0.8 μs (Max
  t_f = 0.25 μs (Max)

50 AMPERE
POWER TRANSISTORS
NPN SILICON
100, 120, 140, 150 VOLTS
250 WATTS



*MAXIMUM RATINGS

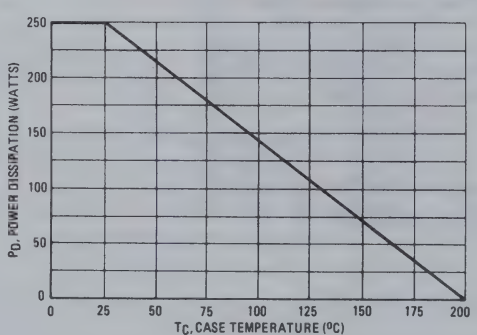
Rating	Symbol	2N6274	2N6275	2N6276	2N6277	Unit
Collector-Base Voltage	V_{CB}	120	140	160	180	Vdc
Collector-Emitter Voltage	V_{CEO}	100	120	140	150	Vdc
Emitter-Base Voltage	V_{EB}	6.0				Vdc
Collector Current – Continuous Peak	I_C	50 100				Adc
Base Current	I_B	20				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	250 1.43				Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200				°C

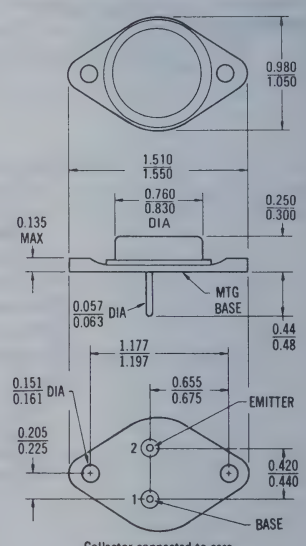
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





Collector connected to case
TO-3 Except pin diameter

CASE 197

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

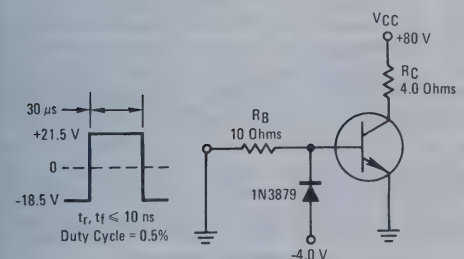
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6274		100	–	
	2N6275		120	–	
	2N6276		140	–	
	2N6277		150	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6274		–	50	
(V_{CE} = 60 Vdc, I_B = 0)	2N6275		–	50	
(V_{CE} = 70 Vdc, I_B = 0)	2N6276		–	50	
(V_{CE} = 75 Vdc, I_B = 0)	2N6277		–	50	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)			–	10	μAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	1.0	mAdc
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{BE} = 6.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			50	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)			30	120	
(I_C = 50 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.0	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.8	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.5	
Base-Emitter On Voltage		$V_{BE(on)}$	–	1.8	Vdc
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2)		f_T	30	–	MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)					
Output Capacitance		C_{ob}	–	600	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
SWITCHING CHARACTERISTICS					
Rise Time		t_r	–	0.35	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = 2.0 Adc, $V_{BE(off)}$ = 5.0 Vdc)					
Storage Time		t_s	–	0.80	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)					
Fall Time		t_f	–	0.25	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)					

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



Note: For information on Figures 3 and 6, R_B and R_C were varied to obtain desired test conditions.

FIGURE 3 – TURN-ON TIME

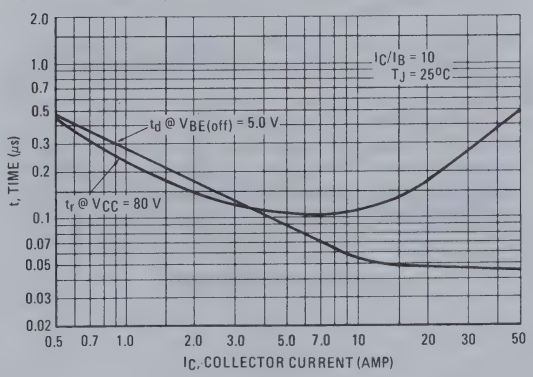


FIGURE 4 – THERMAL RESPONSE

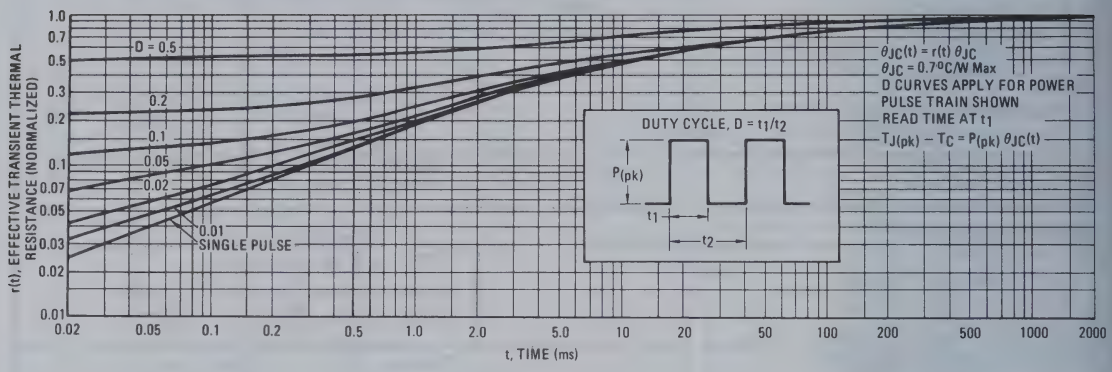
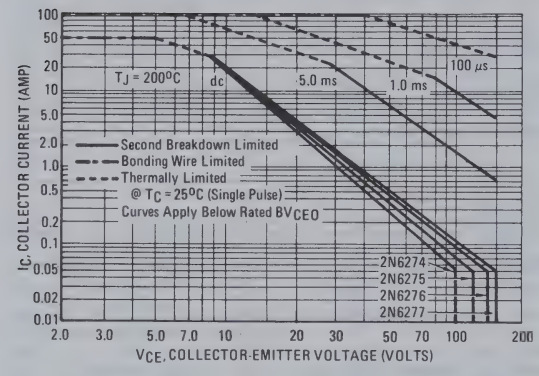


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

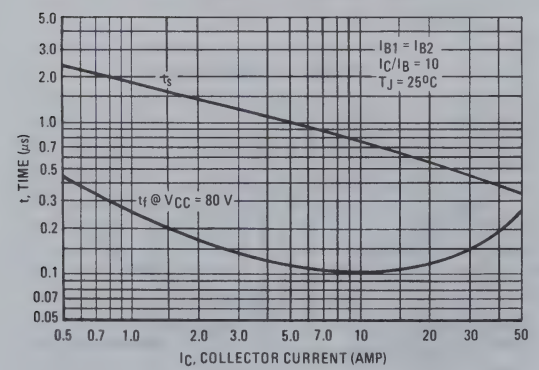


FIGURE 7 – CAPACITANCE

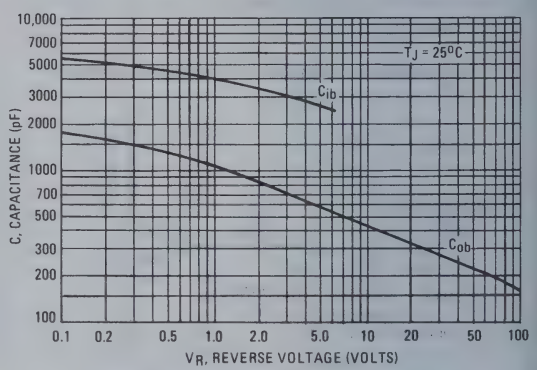


FIGURE 8 – DC CURRENT GAIN

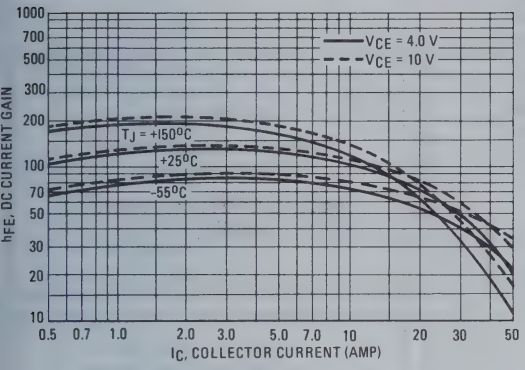


FIGURE 9 – COLLECTOR SATURATION REGION

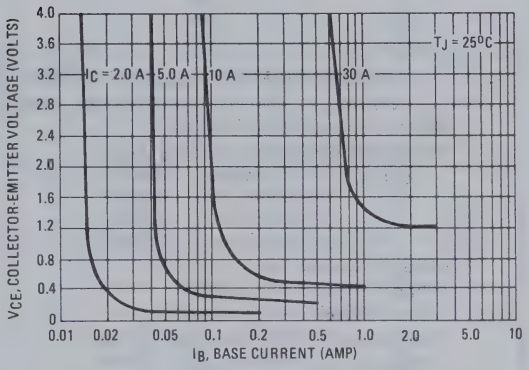


FIGURE 10 – "ON" VOLTAGES

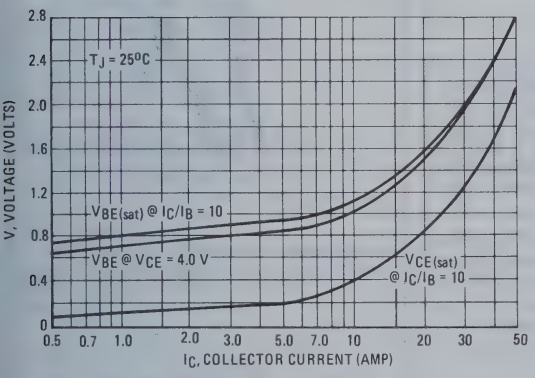


FIGURE 11 – TEMPERATURE COEFFICIENTS

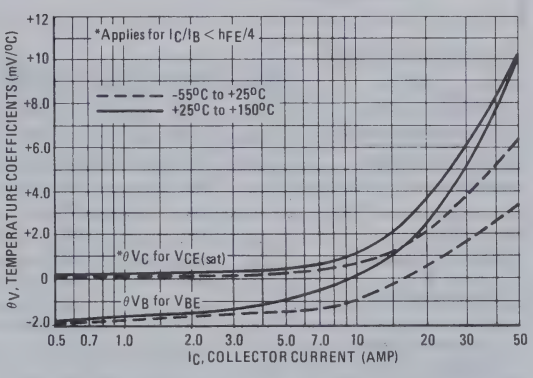


FIGURE 12 – COLLECTOR CUT-OFF REGION

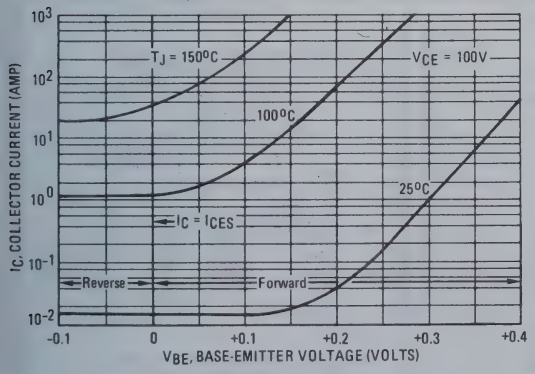
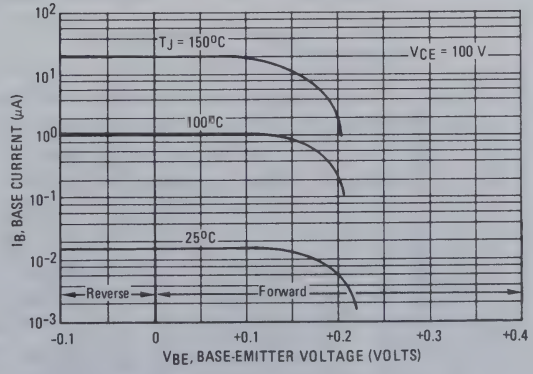


FIGURE 13 – BASE CUT-OFF REGION



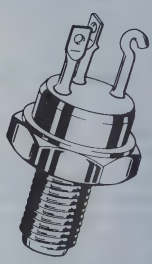
2N6278 thru 2N6281 (SILICON)

HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

- High Collector Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 100 Vdc (Min) — 2N6278
  = 120 Vdc (Min) — 2N6279
  = 140 Vdc (Min) — 2N6280
  = 150 Vdc (Min) — 2N6281
- High DC Current Gain —
  h_{FE} = 30-120 @ I_C = 20 Adc
  = 10 (Min) @ I_C = 50 Adc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 20 Adc
- Fast Switching Times @ I_C = 20 Adc
  t_r = 0.35 μs (Max)
  t_s = 0.8 μs (Max)
  t_f = 0.25 μs (Max)

50 AMPERE
POWER TRANSISTORS
NPN SILICON
100, 120, 140, 150 VOLTS
250 WATTS



*MAXIMUM RATINGS

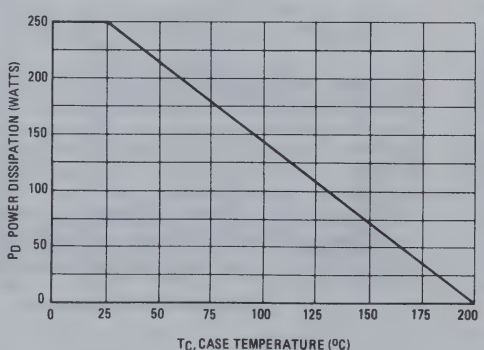
Rating	Symbol	2N6278	2N6279	2N6280	2N6281	Unit
Collector-Base Voltage	V_{CB}	120	140	160	180	Vdc
Collector-Emitter Voltage	V_{CEO}	100	120	140	150	Vdc
Emitter-Base Voltage	V_{EB}	6.0				Vdc
Collector Current — Continuous Peak	I_C	50 100				Adc
Base Current	I_B	20				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	250 1.43				Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200				°C

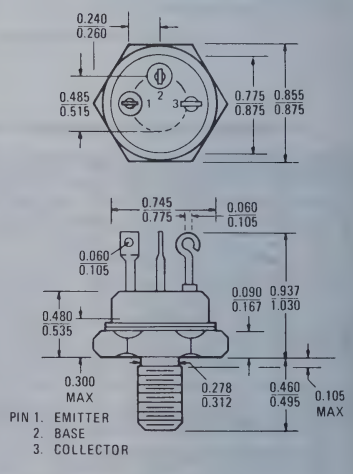
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.70	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 — POWER DERATING





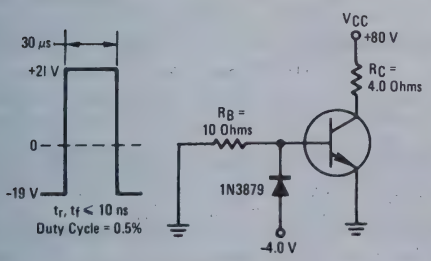
CASE 188
Collector connected to case.

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6278		100	–	
	2N6279		120	–	
	2N6280		140	–	
	2N6281		150	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6278		–	50	
(V_{CE} = 60 Vdc, I_B = 0)	2N6279		–	50	
(V_{CE} = 70 Vdc, I_B = 0)	2N6280		–	50	
(V_{CE} = 75 Vdc, I_B = 0)	2N6281		–	50	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)			–	10	μAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C			–	1.0	mAdc
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{BE} = 6.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			50	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)			30	120	
(I_C = 50 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	–		Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.2	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.8	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.5	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2)		f_T	30	–	MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)					
Output Capacitance		C_{ob}	–	600	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
SWITCHING CHARACTERISTICS					
Rise Time		t_r	–	0.35	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = 2.0 Adc, $V_{BE\ (off)}$ = 5.0 Vdc)					
Storage Time		t_s	–	0.80	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)					
Fall Time		t_f	–	0.25	μs
(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)					

*Indicates JEDEC Registered Data (1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%. (2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



Note: For information on Figures 3 & 6, R_B and R_C were varied to obtain desired test conditions.

FIGURE 3 – TURN ON TIME

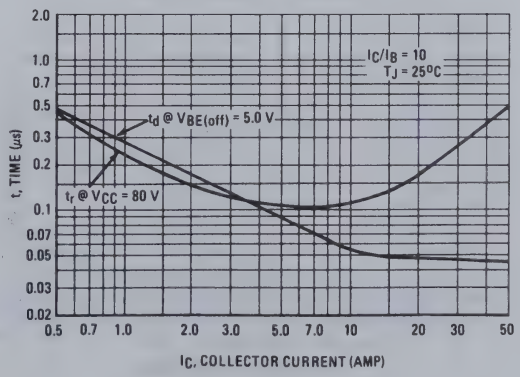


FIGURE 4 – THERMAL RESPONSE

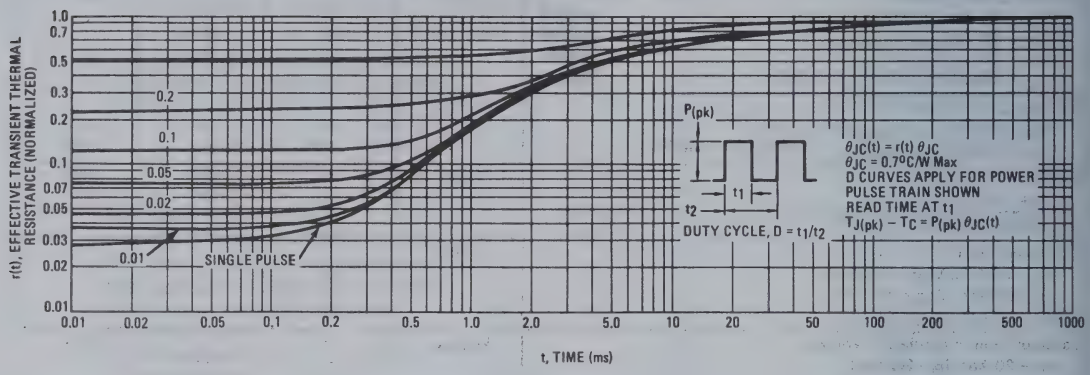
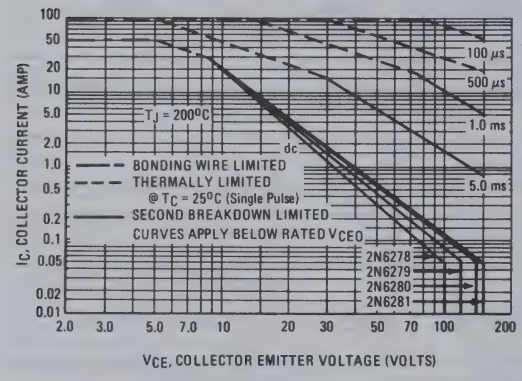


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN OFF TIME

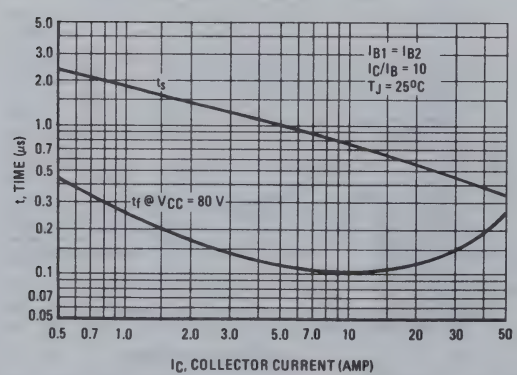


FIGURE 7 – CAPACITANCE

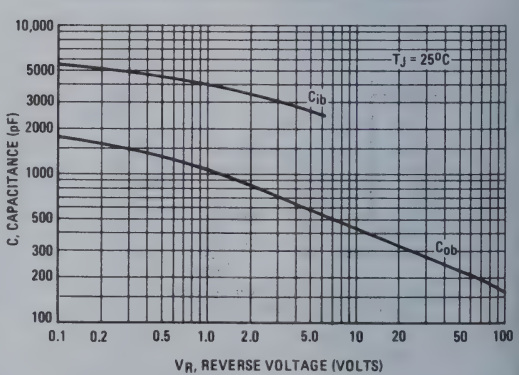


FIGURE 8 – DC CURRENT GAIN

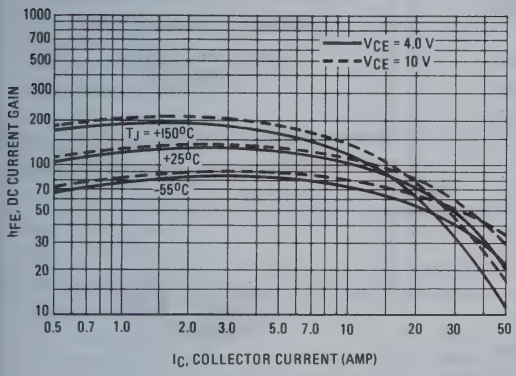


FIGURE 9 – COLLECTOR SATURATION REGION

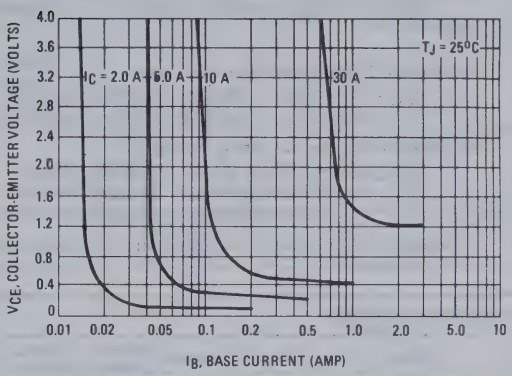


FIGURE 10 – ON VOLTAGES

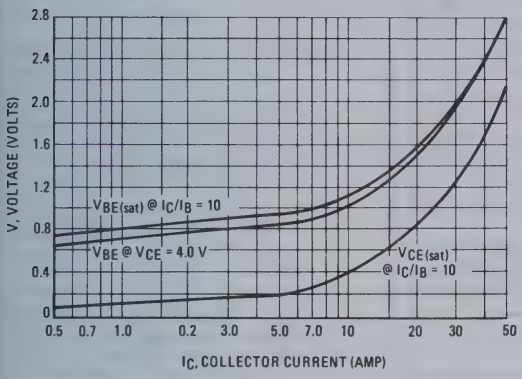


FIGURE 11 – TEMPERATURE COEFFICIENTS

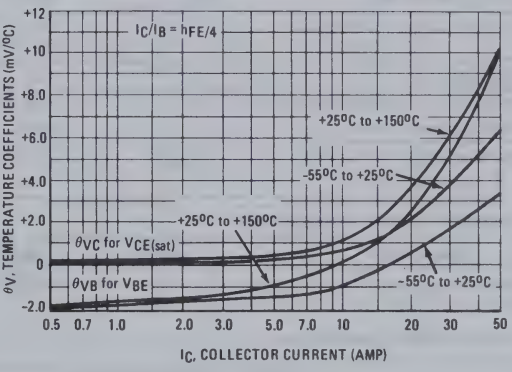


FIGURE 12 – COLLECTOR CUTOFF REGION

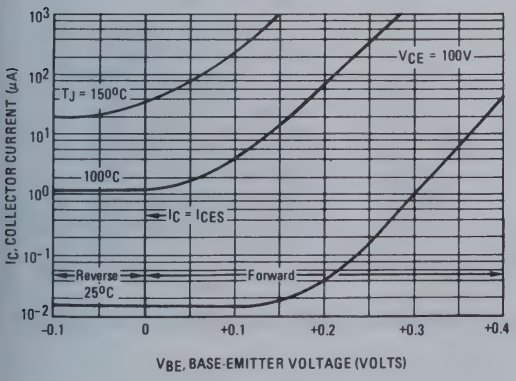
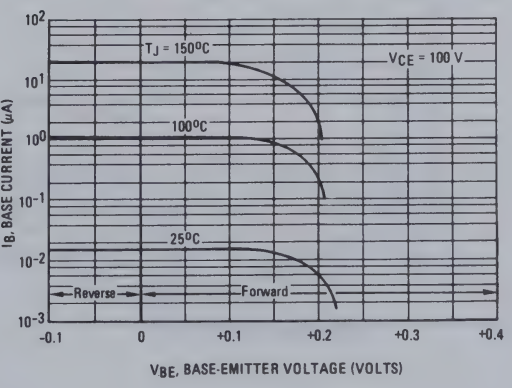


FIGURE 13 – BASE CUTOFF REGION



2N6282 thru 2N6284 NPN (SILICON)
2N6285 thru 2N6287 PNP

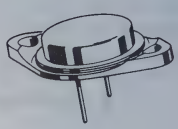
DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and low-speed switching applications.

- High DC Current Gain @ I_C = 10 Adc –
  h_{FE} = 2400 (Typ) – 2N6282, 2N6283, 2N6284
  = 4000 (Typ) – 2N6285, 2N6286, 2N6287
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 60 Vdc (Min) – 2N6282, 2N6285
  = 80 Vdc (Min) – 2N6283, 2N6286
  = 100 Vdc (Min) – 2N6284, 2N6287
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

DARLINGTON 20 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

60, 80, 100 VOLTS
160 WATTS



*MAXIMUM RATINGS

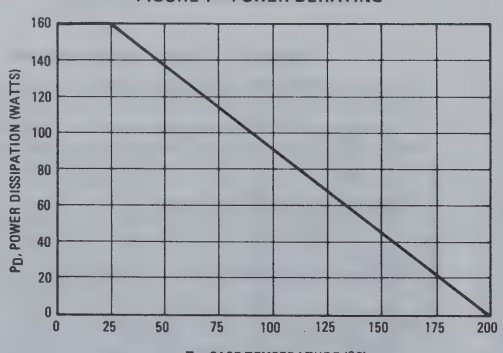
Rating	Symbol	2N6282 2N6285	2N6283 2N6286	2N6284 2N6287	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous Peak	I_C	20 40			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	160 0.915			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200			°C

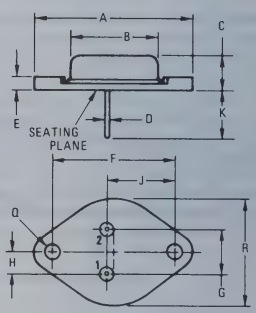
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.09	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

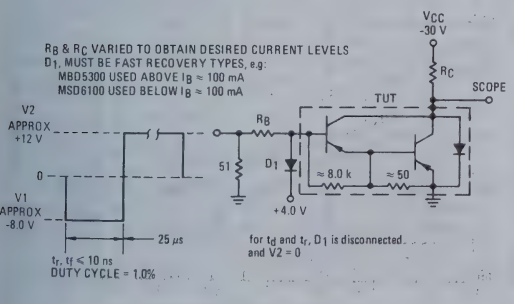
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 0.1 Adc, I_B = 0)	2N6282, 2N6285		60	–	
	2N6283, 2N6286		80	–	
	2N6284, 2N6287		100	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N6282, 2N6285		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N6283, 2N6286		–	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N6284, 2N6287		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	0.5	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Emitter Cutoff Current		I_{EBO}	–	2.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 10 Adc, V_{CE} = 3.0 Vdc)			750	18,000	
(I_C = 20 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 40 mAdc)			–	2.0	
(I_C = 20 Adc, I_B = 200 mAdc)			–	3.0	
Base-Emitter On Voltage		$V_{BE(on)}$	–	2.8	Vdc
(I_C = 10 Adc, V_{CE} = 3.0 Vdc)					
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	–	4.0	Vdc
(I_C = 20 Adc, I_B = 200 mAdc)					
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short-Circuit Forward Current Transfer Ratio		$\lvert h_{fe} \rvert$	4.0	–	MHz
(I_C = 10 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)					
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N6282, 83, 84		–	400	
	2N6285, 86, 87		–	600	
Small-Signal Current Gain		h_{fe}	300	–	–
(I_C = 10 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data.

(1) Pulse test: Pulse Width = 300 μs, Duty Cycle = 2%

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit reverse diode and voltage polarities.

FIGURE 3 – SWITCHING TIMES

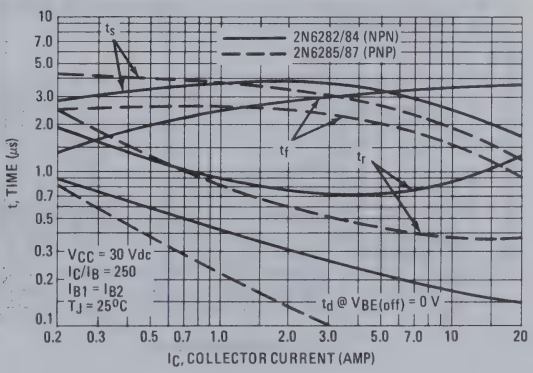
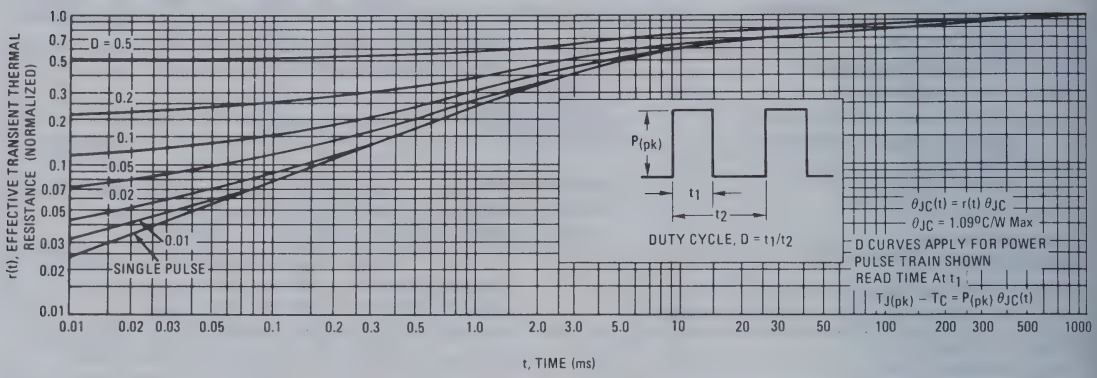


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – 2N6282, 2N6285

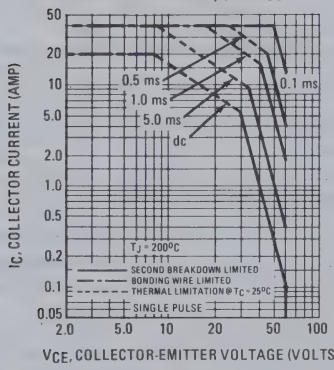


FIGURE 6 – 2N6283, 2N6286

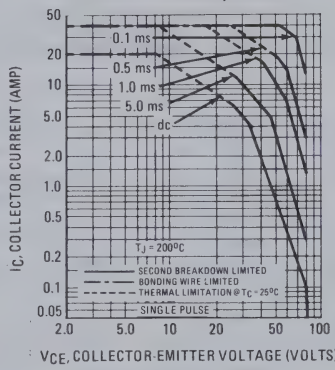
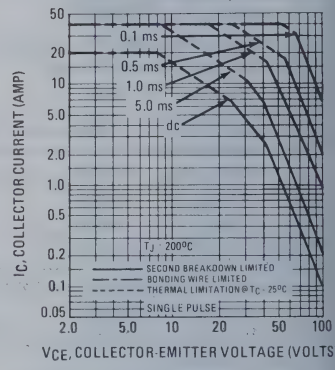


FIGURE 7 – 2N6284, 2N6287



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5, 6 and 7 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 8 – SMALL-SIGNAL CURRENT GAIN

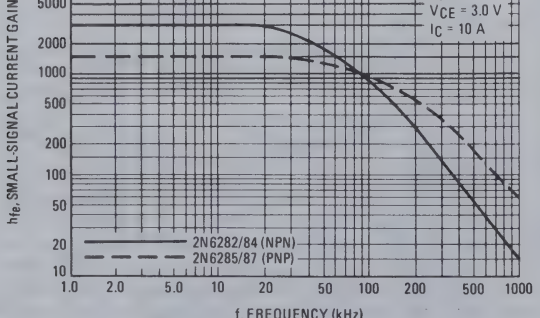
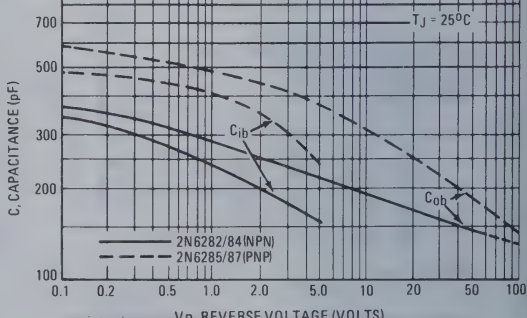


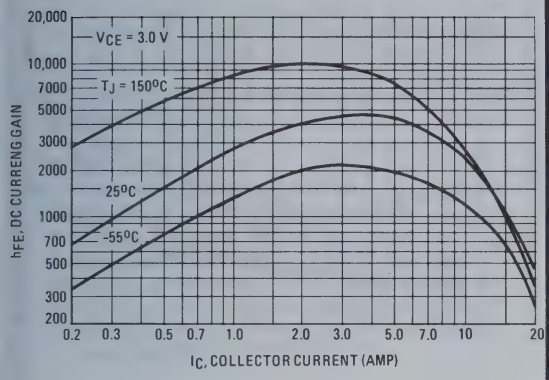
FIGURE 9 – CAPACITANCE



NPN
2N6282, 2N6283, 2N6284

PNP
2N6285, 2N6286, 2N6287

FIGURE 10 – DC CURRENT GAIN



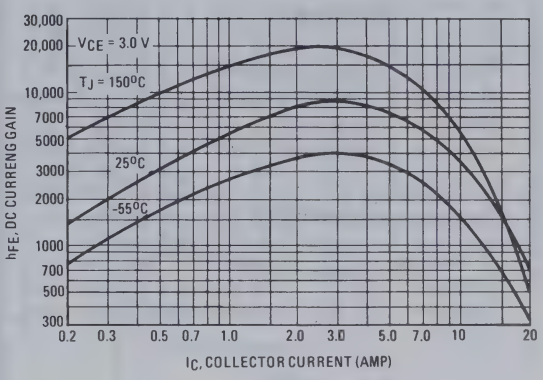
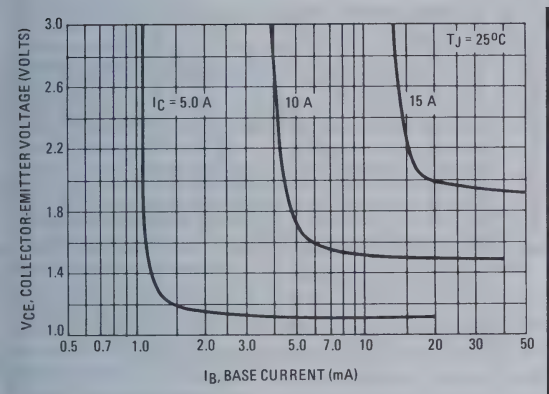


FIGURE 11 – COLLECTOR SATURATION REGION



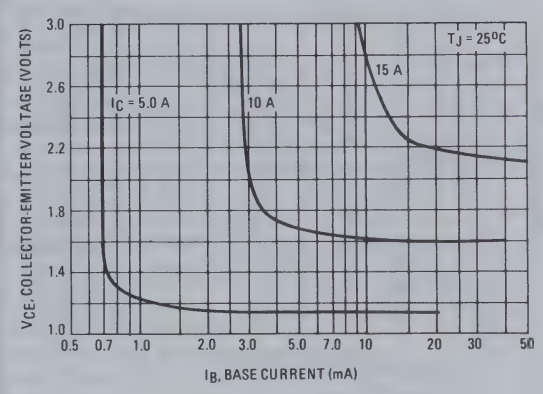
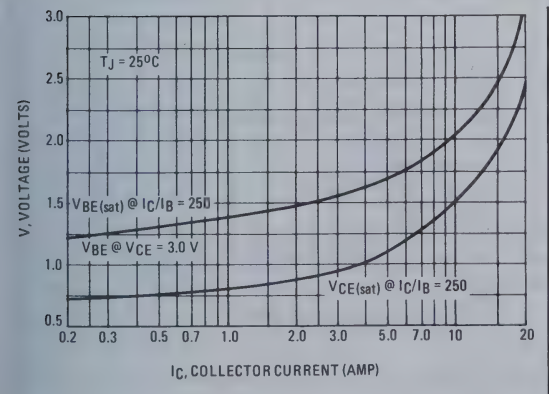
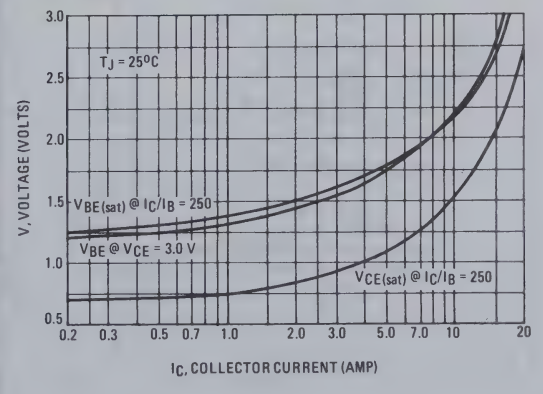


FIGURE 12 – "ON" VOLTAGES





NPN
2N6282, 2N6283, 2N6284

PNP
2N6285, 2N6286, 2N6287

FIGURE 13 – TEMPERATURE COEFFICIENTS

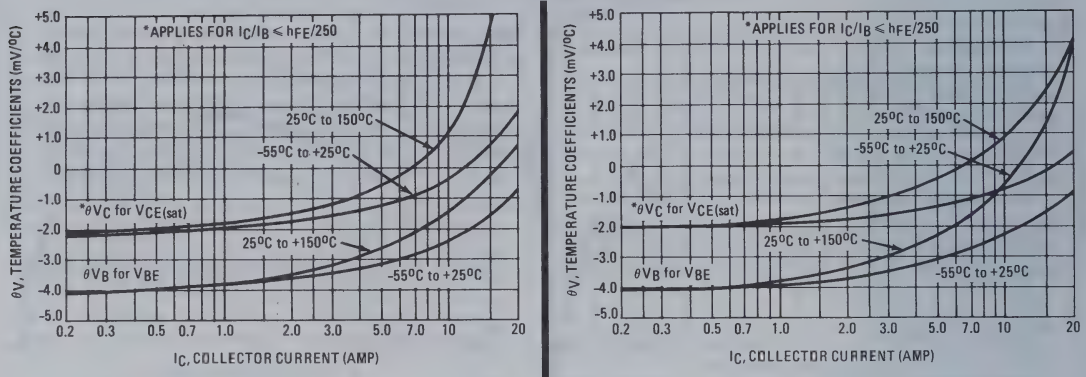


FIGURE 14 – COLLECTOR CUTOFF REGION

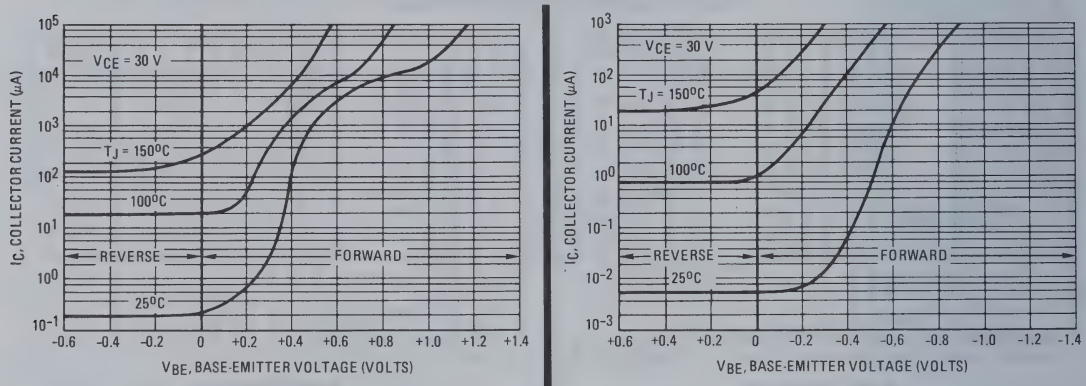
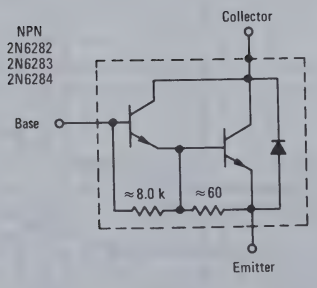
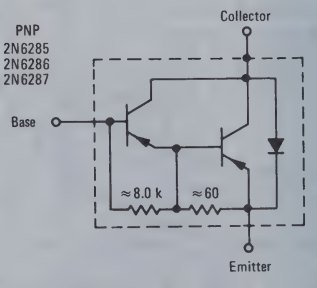


FIGURE 15 – DARLINGTON SCHEMATIC





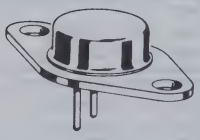
2N6294, 2N6295 NPN (SILICON)
2N6296, 2N6297 PNP

DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier, low-speed switching and hammer driver applications.

- High DC Current Gain — h_{FE} = 3000 (Typ) @ I_C = 2.0 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 2.0 Vdc (Max) @ I_C = 2.0 Adc
- Collector-Emitter Sustaining Voltage
  $V_{CEO(sus)}$ = 60 Vdc (Min) — 2N6294, 2N6296
  = 80 Vdc (Min) — 2N6295, 2N6297
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

4 AMPERES
DARLINGTON COMPLEMENTARY SILICON POWER TRANSISTORS
60, 80 VOLTS
50 WATTS



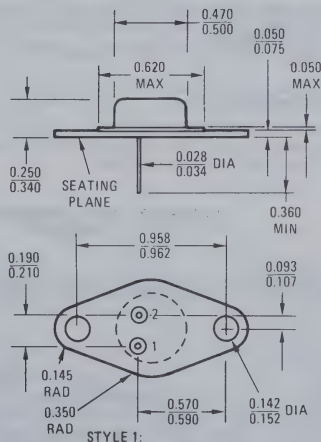
***MAXIMUM RATINGS**

Rating	Symbol	2N6294 2N6296	2N6295 2N6297	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 8.0		Adc
Base Current	I_B	80		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.286		Watts W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.5	°C/W

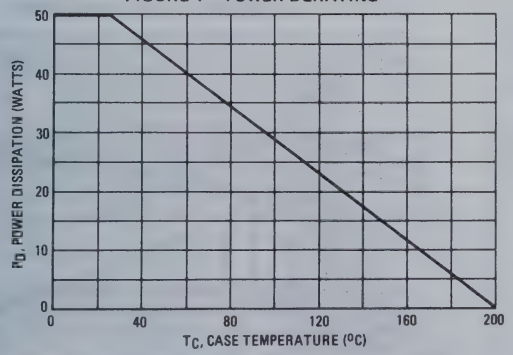
*Indicates JEDEC Registered Data



STYLE 1:
PIN 1. BASE
2. EMITTER
All JEDEC dimensions and notes apply
Collector Connected to Case

CASE 80-02
TO-66

FIGURE 1 — POWER DERATING

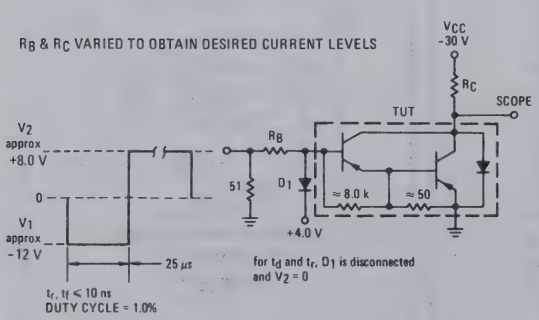


***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	2N6294, 2N6296	$V_{CEO(sus)}$	60	–	Vdc
	2N6295, 2N6297		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N6294, 2N6296		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N6295, 2N6297		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)	2N6294, 2N6295		–	0.5	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)	2N6296, 2N6297		–	0.5	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6294, 2N6295		–	5.0	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6296, 2N6297		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)			750	18000	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 8.0 mAdc)			–	2.0	
(I_C = 4.0 Adc, I_B = 40 mAdc)			–	3.0	
Base-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 40 mAdc)		$V_{BE(sat)}$	–	4.0	Vdc
Base-Emitter On Voltage (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short-Circuit Forward Current Transfer Ratio (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	4.0	–	–
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	2N6294, 2N6295		–	120	
	2N6296, 2N6297		–	200	
Small-Signal Current Gain (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

*Indicates JEDEC Registered Data

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit, reverse all polarities.

FIGURE 3 – SWITCHING TIMES

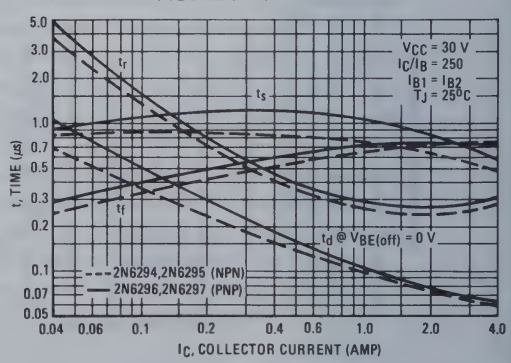


FIGURE 4 – THERMAL RESPONSE

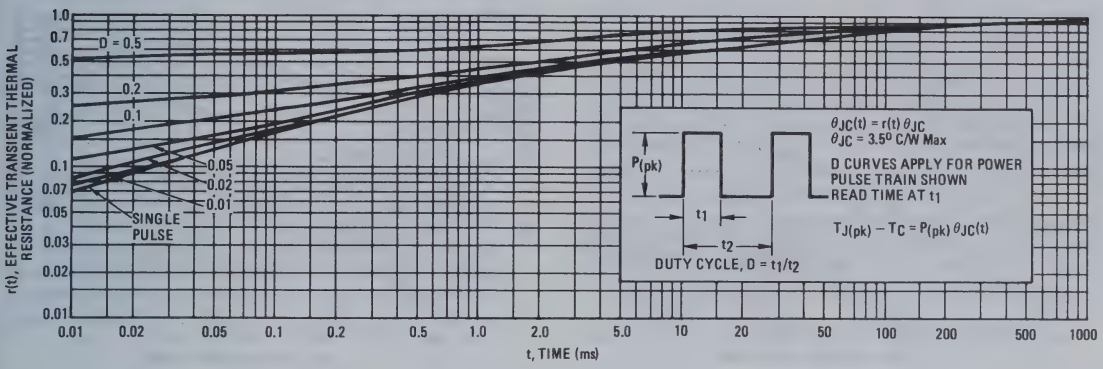
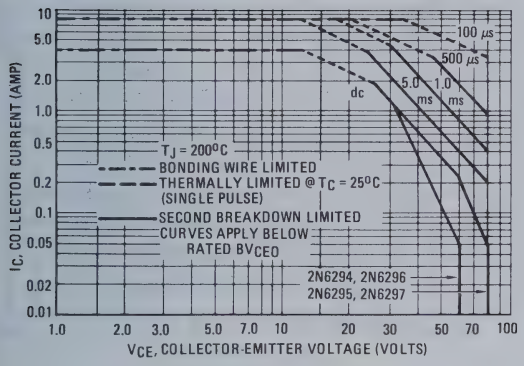


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

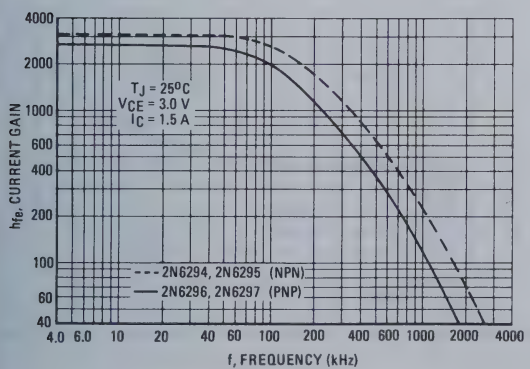
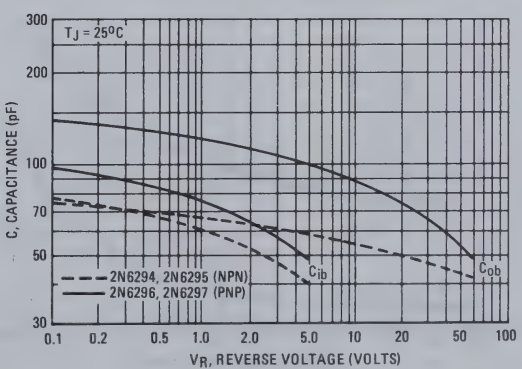


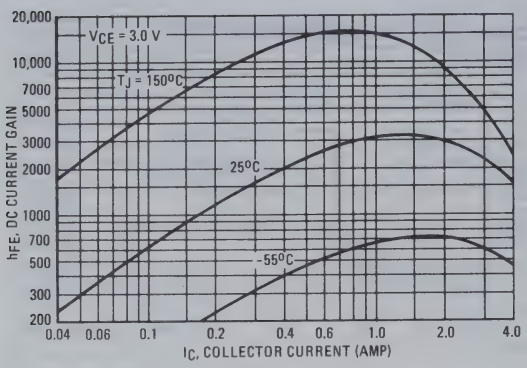
FIGURE 7 – CAPACITANCE



NPN
2N6294, 2N6295

PNP
2N6296, 2N6297

FIGURE 8 – DC CURRENT GAIN



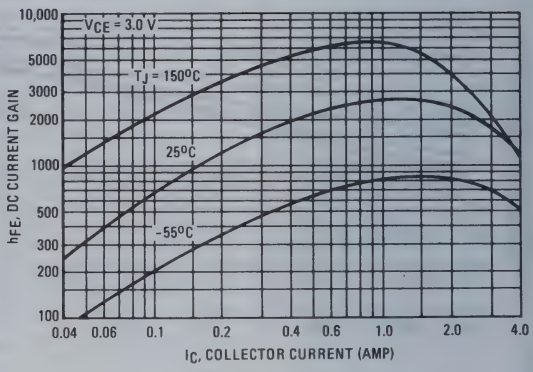
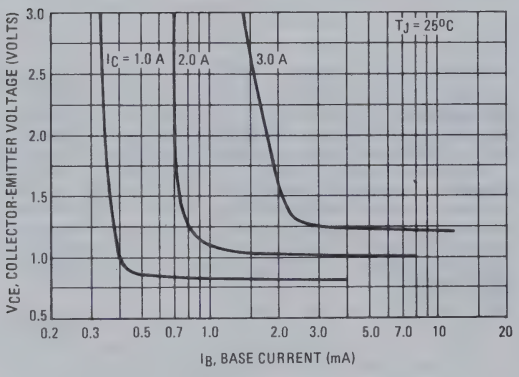


FIGURE 9 – COLLECTOR SATURATION REGION



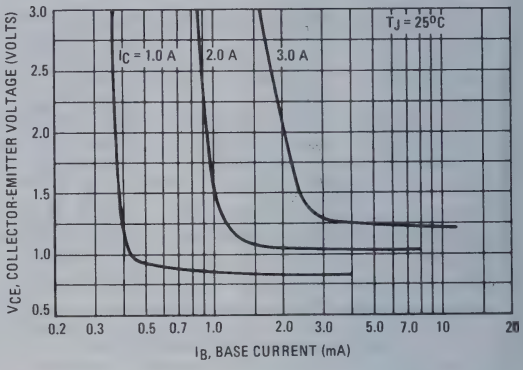
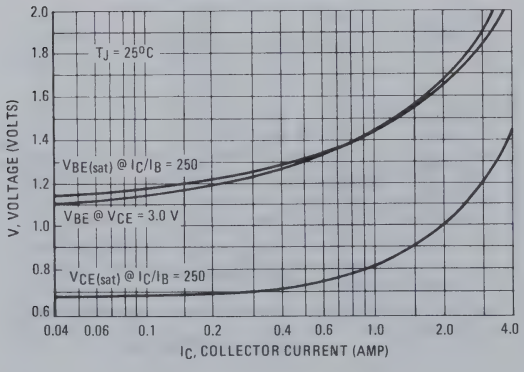
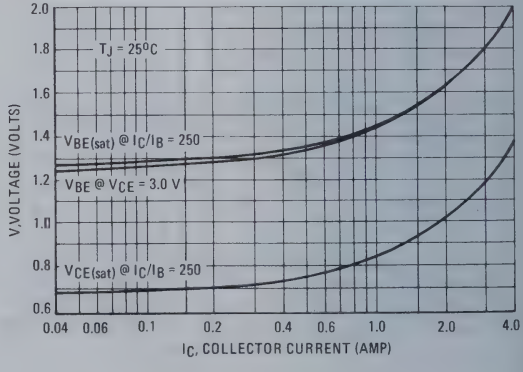


FIGURE 10 – "ON" VOLTAGES





NPN
2N6294, 2N6295

PNP
2N6296, 2N6297

FIGURE 11 – TEMPERATURE COEFFICIENTS

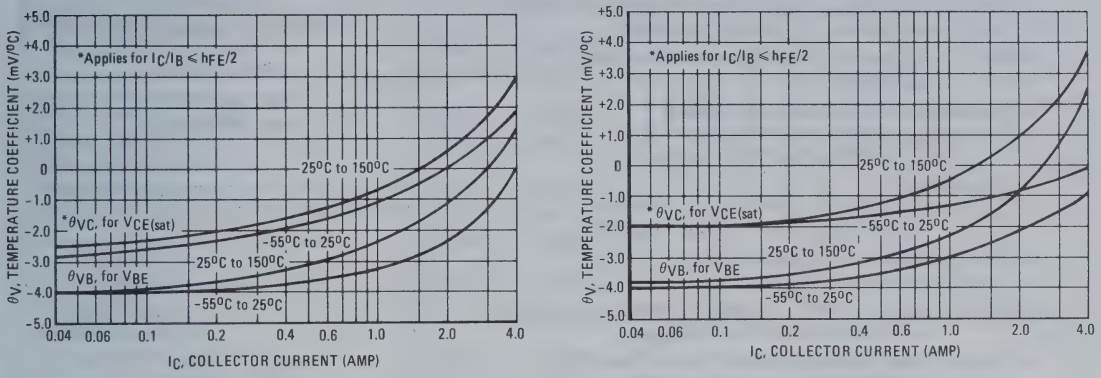


FIGURE 12 – COLLECTOR CUTOFF REGION

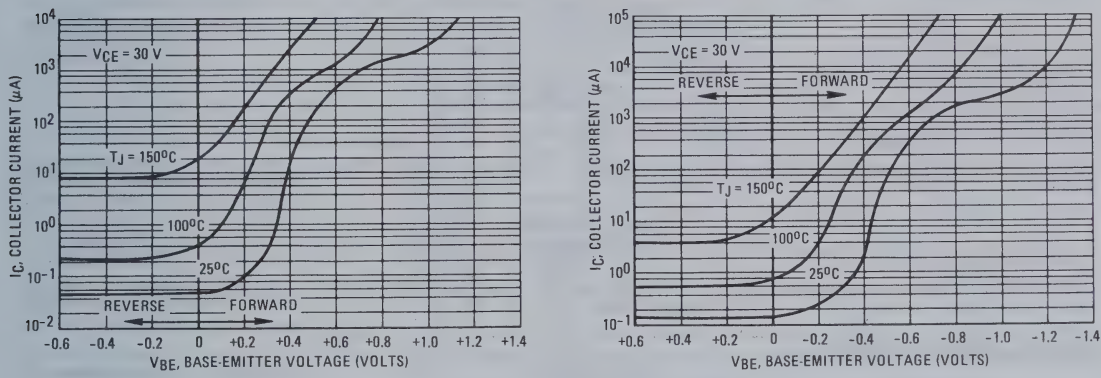
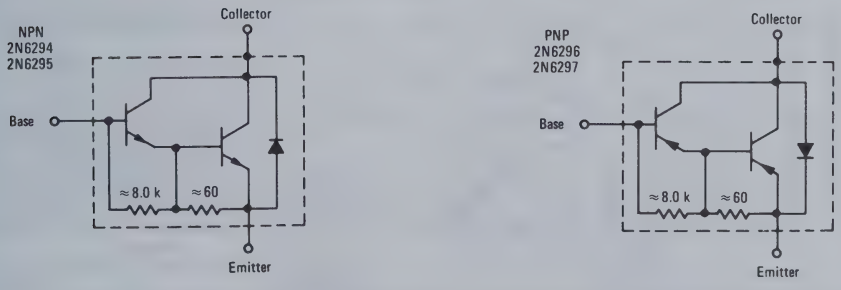


FIGURE 13 – DARLINGTON SCHEMATICS



2N6298 thru 2N6301 NPN (SILICON)

For Specifications, See 2N6053 Data.

2N6302, 2N3773 (SILICON)
MJ6302, MJ3773

HIGH POWER NPN SILICON POWER TRANSISTORS

Epi-Base and Uni-Base (Single Diffused) transistors for ultimate circuit performance based on the designer's requirement.

EPI-BASE — designed for power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 8.0 Adc
  = 2.0 Vdc (Max) @ I_C = 16 Adc
- Low Leakage —
  I_{CBO} = 1.0 mAdc @ V_{CB} = 125 Vdc — MJ6302
  = 1.0 mAdc @ V_{CB} = 140 Vdc — MJ3773
- High Current-Gain — Bandwidth Product —
  f_T = 1.0 MHz (Min) @ I_C = 1.0 Adc

UNI-BASE (Single Diffused) — designed for series pass regulators and inductive switching applications.

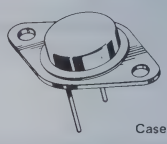
- Forward Biased Second Breakdown Current Capability —
  $I_{S/b}$ = 0.9 Adc @ V_{CE} = 120 Vdc — 2N6302
  = 0.6 Adc @ V_{CE} = 140 Vdc — 2N3773

16 AMPERE POWER TRANSISTORS

NPN SILICON

120, 140 VOLTS
150, 200 WATTS

Case 1 2N3773
2N6302



Case 11 MJ3773
MJ6302

*MAXIMUM RATINGS

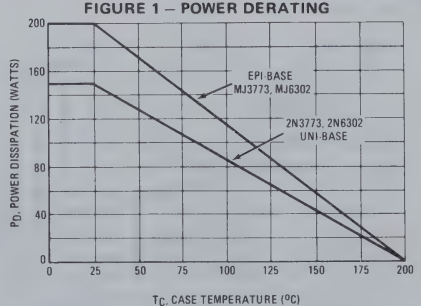
Rating	Symbol	2N6302 MJ6302	2N3773 MJ3773	Unit
Collector-Emitter Voltage	V_{CEO}	120	140	Vdc
Collector-Emitter Voltage	V_{CEX}	140	160	Vdc
Collector-Base Voltage	V_{CB}	140	160	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous Peak	I_C	16 30		Adc
Base Current — Continuous Peak	I_B	4.0 15		Adc
		2N6302 2N3773	MJ6302 MJ3773	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.857	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

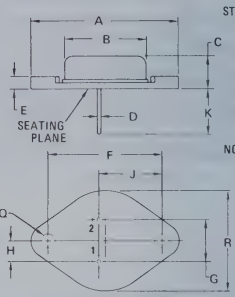
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3773 2N6302	MJ3773 MJ6302	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	0.875	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	—	39.37	—	1.550
B	—	22.23	—	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Uni-Base	Epi-Base	Symbol	Uni-Base Min	Uni-Base Max	Epi-Base Min	Epi-Base Max	Unit
OFF CHARACTERISTICS								
*Collector-Emitter Sustaining Voltage (1) (I_C = 0.2 Adc, I_B = 0)	2N6302 2N3773	MJ6302 MJ3773	$V_{CEO(sus)}$	120 140	– –	120 140	– –	Vdc
*Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, $V_{BE(off)}$ = 1.5 Vdc, R_{BE} = 100 Ohms)	2N6302 2N3773	MJ6302 MJ3773	$V_{CEX(sus)}$	140 160	– –	140 160	– –	Vdc
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, R_{BE} = 100 Ohms)	2N6302 2N3773	MJ6302 MJ3773	$V_{CER(sus)}$	140 160	– –	140 160	– –	Vdc
*Collector Cutoff Current (V_{CE} = 100 Vdc, I_B = 0) (V_{CE} = 120 Vdc, I_B = 0)	2N6302 2N3773	MJ6302 MJ3773	I_{CEO}	– –	10 10	– –	2.0 2.0	mAdc
*Collector Cutoff Current (V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 140 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 140 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6302 2N3773 2N6302 2N3773	MJ6302 MJ3773 MJ6302 MJ3773	I_{CEX}	– – – –	2.0 2.0 10 10	– – – –	1.0 1.0 5.0 5.0	mAdc
Collector Cutoff Current (V_{CB} = 125 Vdc, I_E = 0) (V_{CB} = 140 Vdc, I_E = 0)	2N6302 *2N3773	MJ6302 MJ3773	I_{CBO}	– –	2.0 2.0	– –	1.0 1.0	mAdc
*Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	2N6302 2N3773	MJ6302 MJ3773	I_{EBO}	– –	5.0 5.0	– –	1.0 1.0	mAdc
ON CHARACTERISTICS (1)								
DC Current Gain *(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 16 Adc, V_{CE} = 4.0 Vdc)	2N6302 2N3773 *2N6302 2N3773	MJ6302 MJ3773 MJ6302 MJ3773	h_{FE}	15 15 5.0 5.0	60 60 – –	15 15 5.0 5.0	60 60 – –	–
Collector-Emitter Saturation Voltage *(I_C = 8.0 Adc, I_B = 800 mAdc) (I_C = 16 Adc, I_B = 3.2 Adc)	2N6302 2N3773 *2N6302 2N3773	MJ6302 MJ3773 MJ6302 MJ3773	$V_{CE(sat)}$	– – – –	1.4 1.4 4.0 4.0	– – – –	0.8 0.8 2.0 2.0	Vdc
*Base-Emitter On Voltage (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	2N6302 2N3773	MJ6302 MJ3773	$V_{BE(on)}$	– –	2.2 2.2	– –	1.5 1.5	Vdc
DYNAMIC CHARACTERISTICS								
Current-Gain — Bandwidth Product *(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 0.05 MHz) (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 0.5 MHz)	Uni-Base Epi-Base		f_T	0.2	–	1.0	–	MHz
*Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	Uni-Base	Epi-Base	h_{fe}	40	–	40	–	–
SWITCHING CHARACTERISTICS								
Rise Time Storage Time Fall Time	(V_{CC} = 30 Vdc, I_C = 8.0 Adc, I_{B1} = I_{B2} = 0.8 Adc)	Epi-Base	t_r t_s t_f			– – –	1.5 2.0 1.8	µs µs µs
Second Breakdown Collector Current with base forward biased t = 1.0 s (non-repetitive) (V_{CE} = 30 Vdc) (V_{CE} = 100 Vdc)	2N6302 2N3773		$I_{S/b}$	1.9 1.5	– –			Adc
Second Breakdown Energy with base reverse biased (I_C = 2.5 Adc, V_{BE} = 4.0 Vdc, L = 40 mH, R_{BE} = 100 Ohms)	2N6302 2N3773		$E_{S/b}$	0.125 0.125	– –			J

*Indicates JEDEC Registered Data for 2N3773 and 2N6302.
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 2 – THERMAL RESPONSE – 2N3773, 2N6302

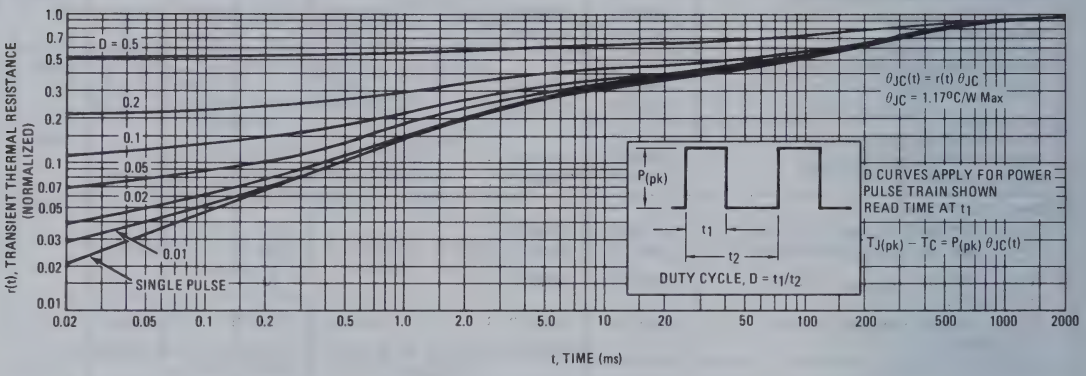
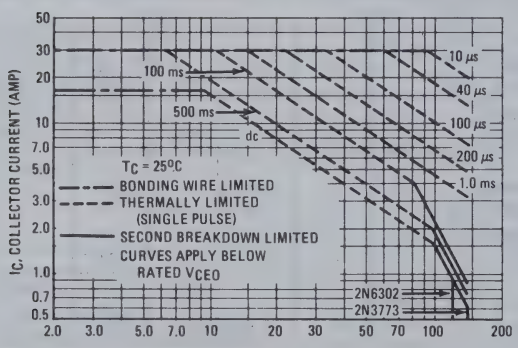


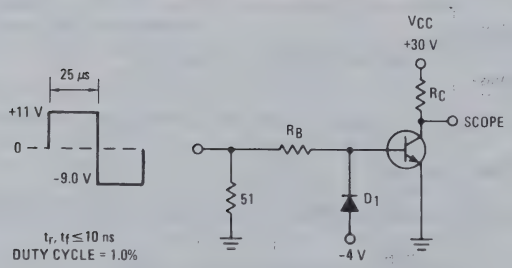
FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA – 2N3773, 2N6302



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. (See AN-415).

Figure 3 is based upon JEDEC registered data. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data of Figure 2. Using data of Figure 2 and the pulse power limits of Figure 3, $T_{J(pk)}$ will be found to be less than $T_{J(max)}$ for pulse widths of 1 ms and less. When using Motorola transistors, it is permissible to increase the pulse power limits until limited by $T_{J(max)}$.

FIGURE 4 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 5 – TURN-ON TIME

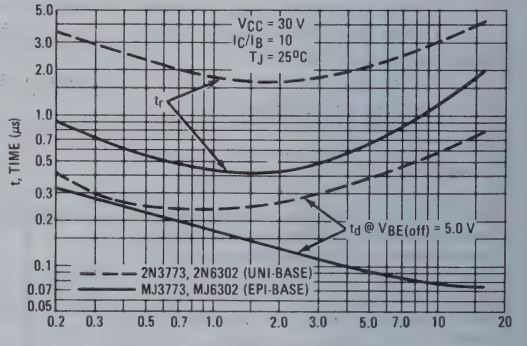


FIGURE 6 – THERMAL RESPONSE – MJ3773, MJ6302

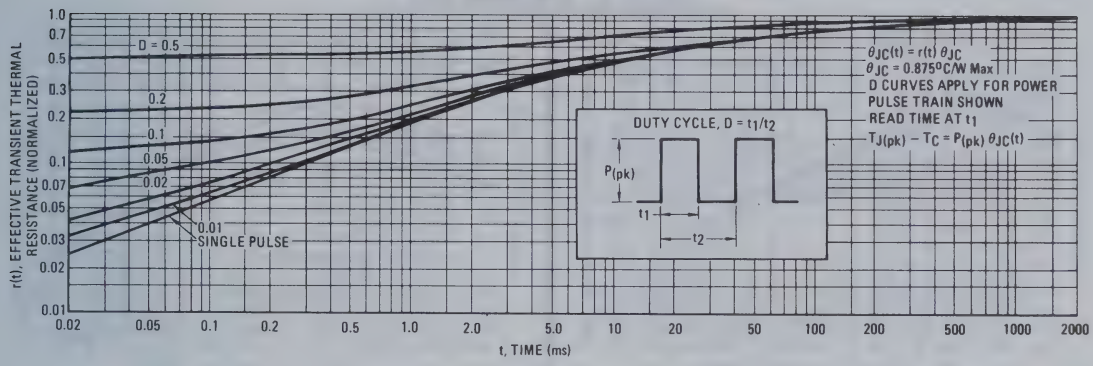
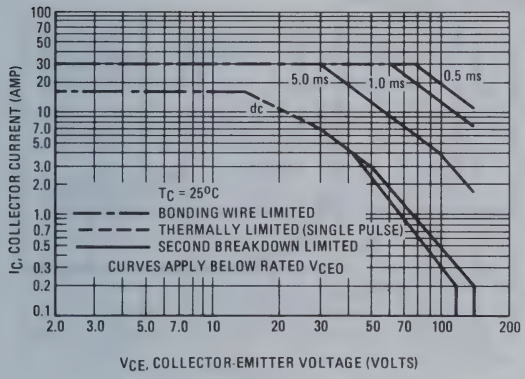


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA – MJ3773, MJ6302



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 8 – TURN-OFF TIME

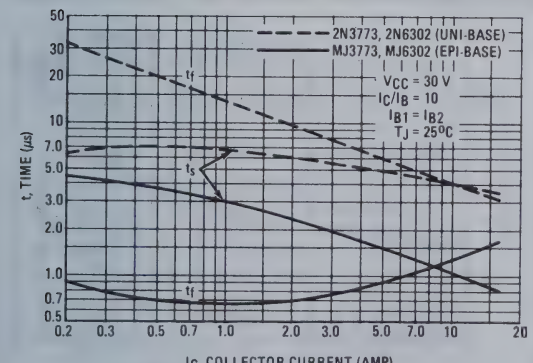
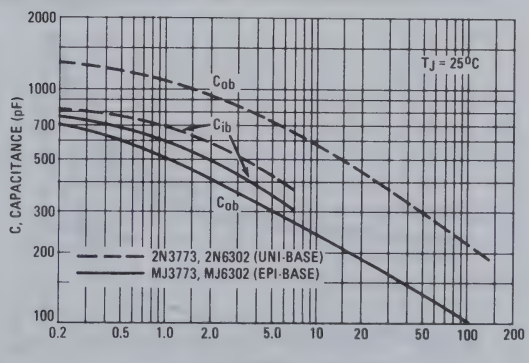


FIGURE 9 – CAPACITANCE



UNI-BASE
2N3773, 2N6302

EPI-BASE
MJ3773, MJ6302

FIGURE 10 – DC CURRENT GAIN

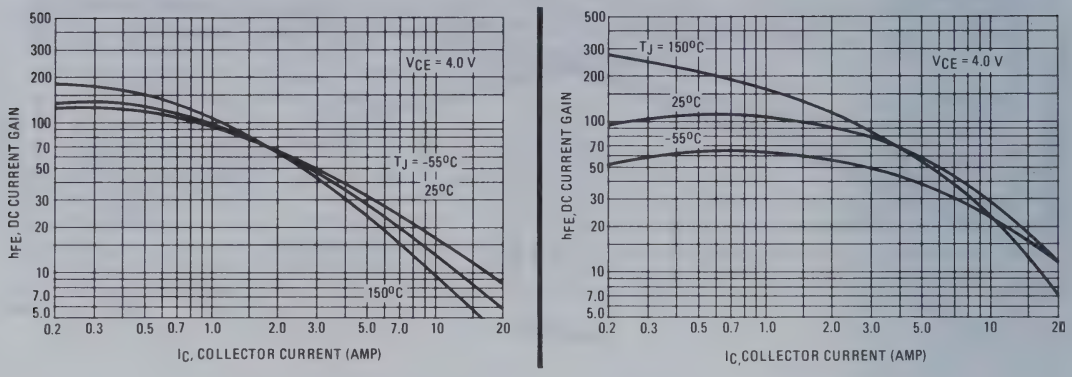


FIGURE 11 – COLLECTOR SATURATION REGION

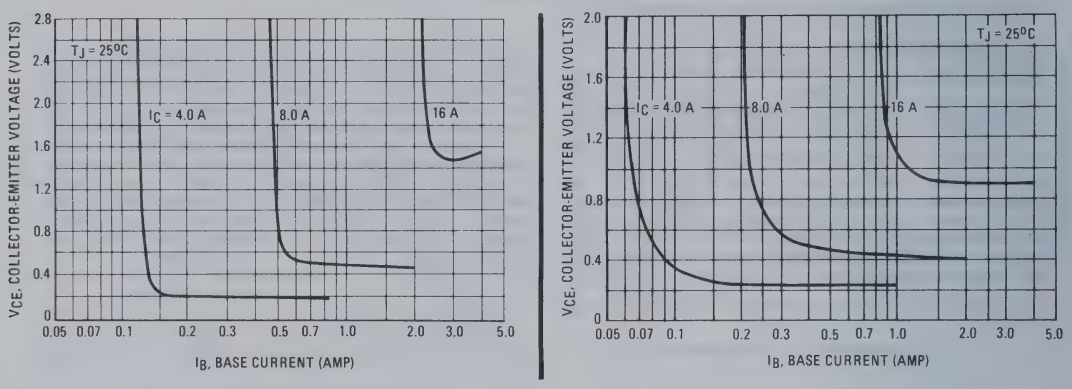
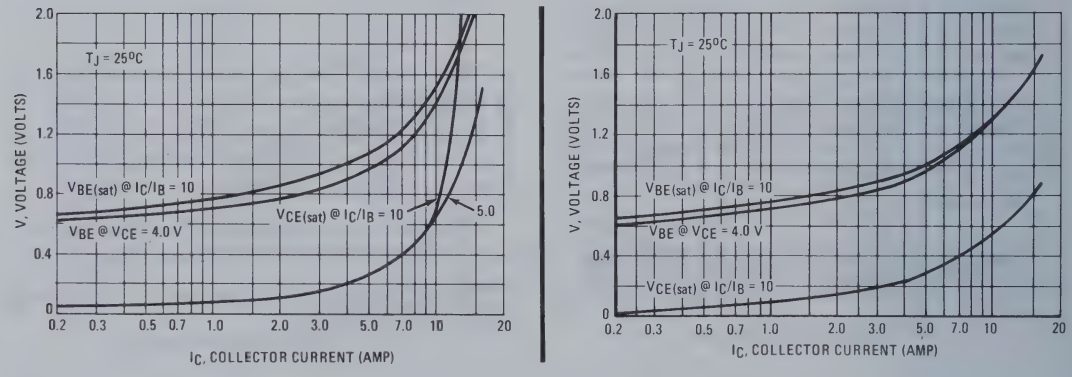


FIGURE 12 – "ON" VOLTAGES



UNI-BASE
2N3773, 2N6302

EPI-BASE
MJ3773, MJ6302

FIGURE 13 – TEMPERATURE COEFFICIENTS

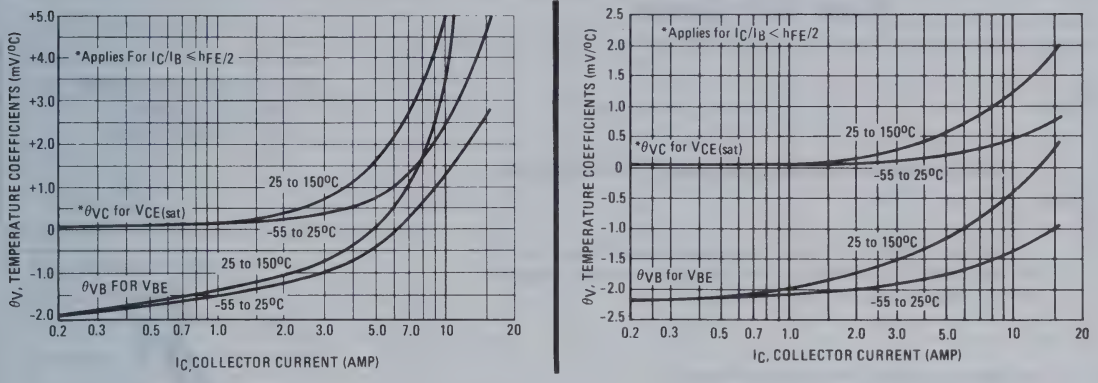
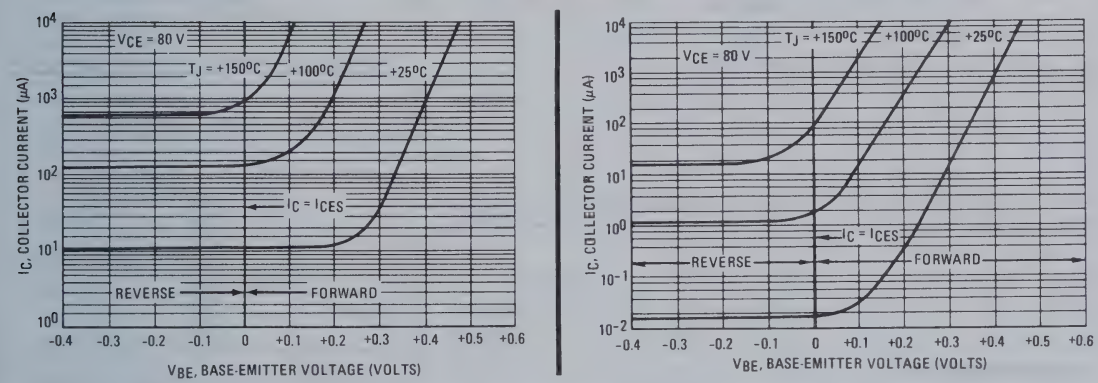


FIGURE 14 – COLLECTOR CUTOFF REGION



2N6303 (SILICON)

For Specifications, See 2N3719 Data.

2N6304 (SILICON)
2N6305

The RF Line

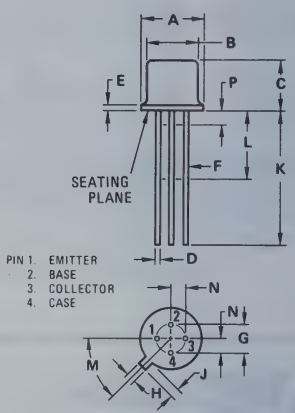
NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in broadband amplifiers to 1.0 GHz, including MATV applications. Also useful as a low-noise, high-gain, general purpose UHF small-signal amplifier.

- High Current-Gain – Bandwidth Product –
  f_T = 1400 MHz (Min) @ I_C = 10 mAdc
- Low Noise Figure –
  NF = 4.5 dB (Max) @ f = 450 MHz
- High Power Gain –
  G_{pe} = 15 dB (Min) @ f = 450 MHz

HIGH-GAIN, LOW NOISE SMALL-SIGNAL UHF TRANSISTORS





***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage 1.0 to 20 mAdc	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CBO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Continuous Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*JEDEC Registered

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

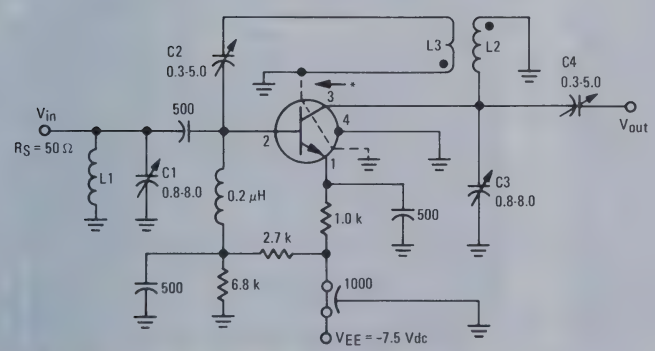
ALL JEDEC dimensions and notes apply
CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)		BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	25	–	250	–
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE}=5.0 Vdc, f=100 MHz)	2N6304 2N6305	f_T	1400 1200	– –	2400 2400	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	0.1	0.8	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	25	–	250	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 5.0 Vdc, f = 31.8 MHz)	2N6304 2N6305	$r_b'C_c$	2.0 2.0	–	12 15	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 50 ohms, f = 450 MHz) (Figure 1)	2N6304 2N6305	NF	– –	– –	4.5 5.5	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc, f = 450 MHz) (Figure 1)	2N6304 2N6305	G_{pe}	15 12	– –	– –	dB

*JEDEC Registered

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

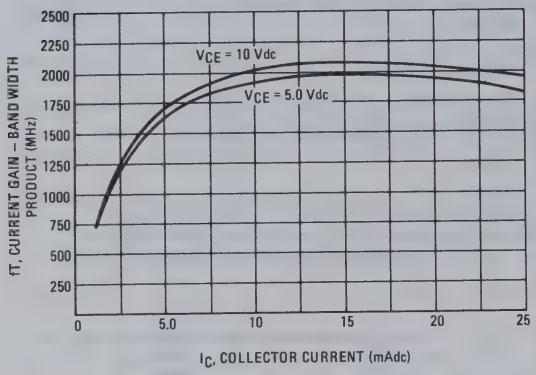


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT versus EMITTER CURRENT

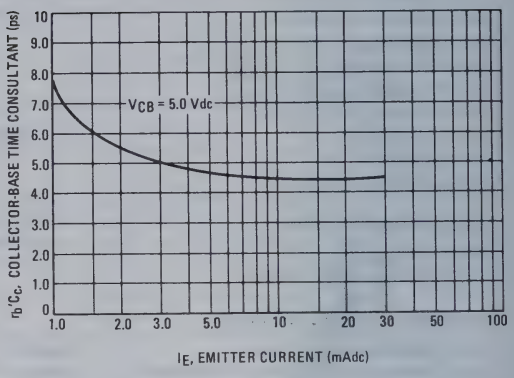


FIGURE 4 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

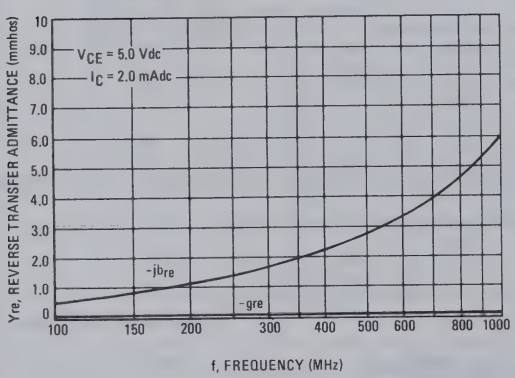


FIGURE 5 – INPUT ADMITTANCE versus FREQUENCY

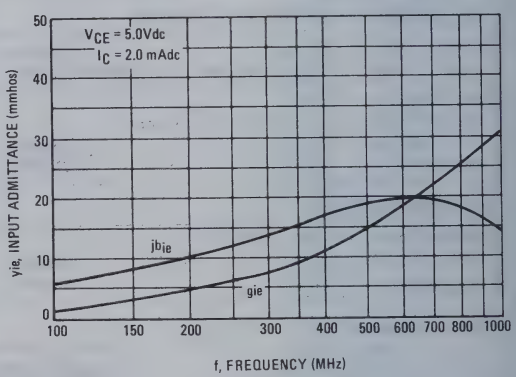


FIGURE 6 – OUTPUT ADMITTANCE versus FREQUENCY

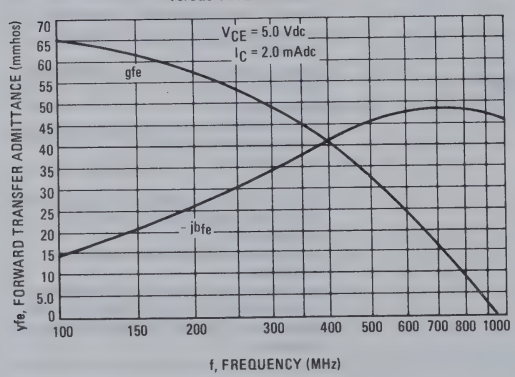


FIGURE 7 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

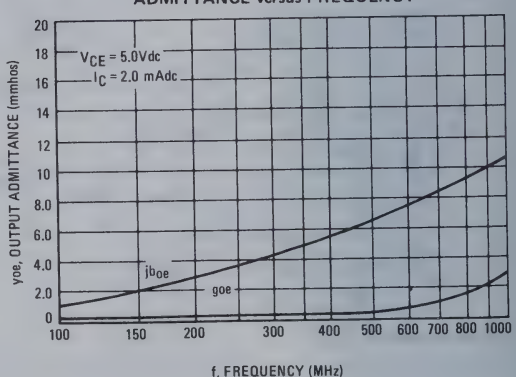


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus COLLECTOR BASE VOLTAGE

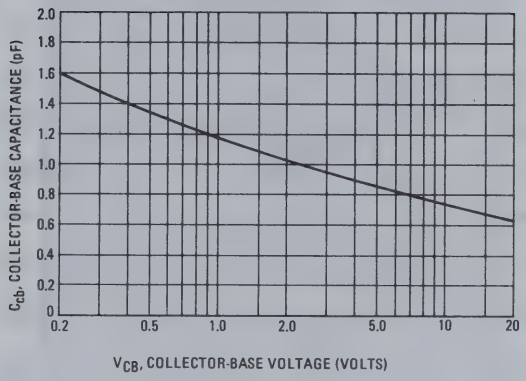


FIGURE 9 – S_{11}, INPUT REFLECTION COEFFICIENT

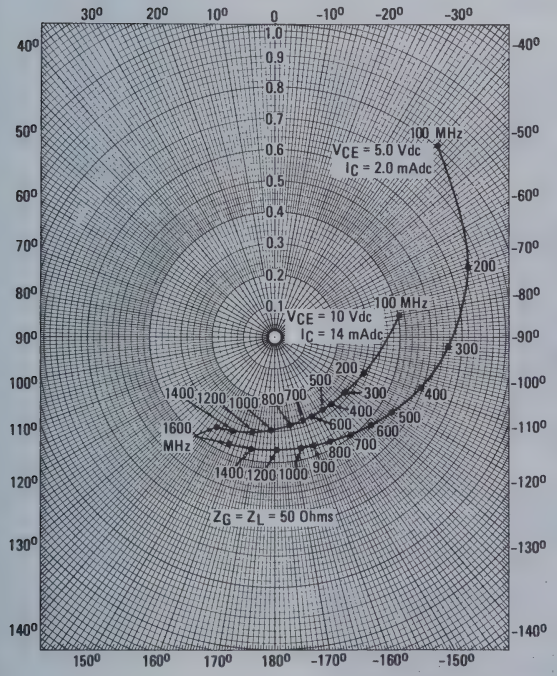


FIGURE 10 – S_{22}, OUTPUT REFLECTION COEFFICIENT

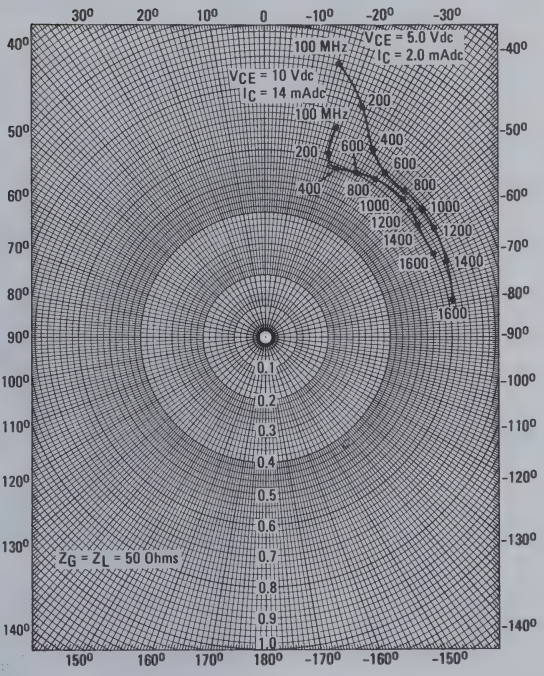


FIGURE 11 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

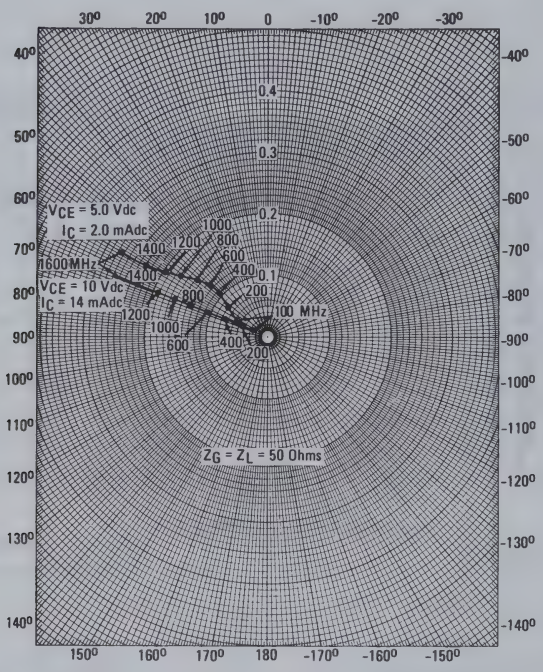


FIGURE 12 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

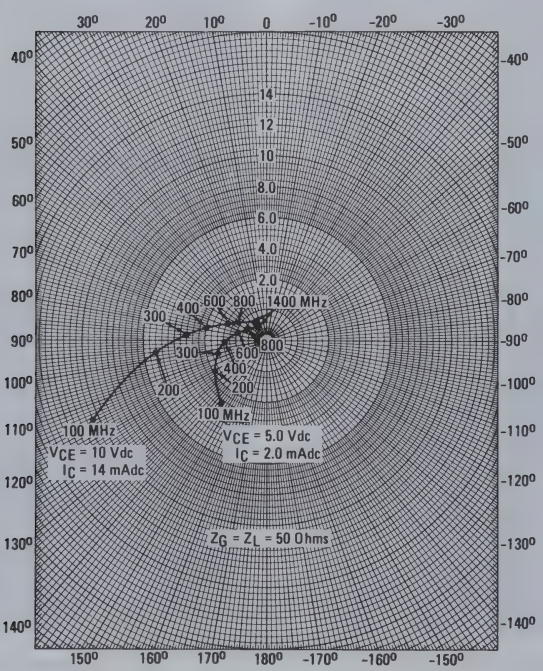
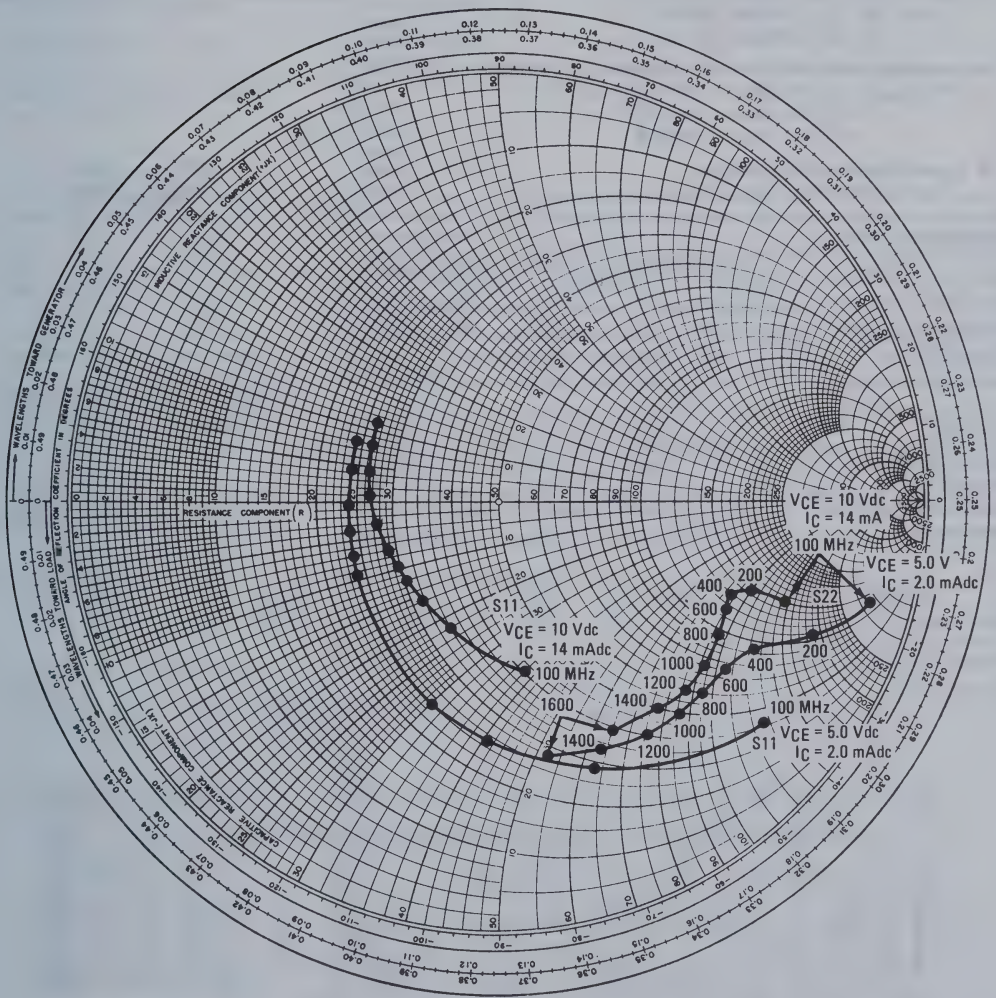


FIGURE 13 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N6306 (SILICON)
2N6307
2N6308

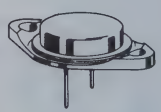
HIGH VOLTAGE NPN SILICON POWER TRANSISTORS

. . . designed for high voltage inverters, switching regulators and line-operated amplifier applications. Especially well suited for switching power supply applications in associated consumer products.

- High Collector-Base Voltage –
  V_{CB} = 500 Vdc – 2N6306
  = 600 Vdc – 2N6307
  = 700 Vdc – 2N6308
- Excellent DC Current Gain @ I_C = 3.0 Adc
  h_{FE} = 15 - 75 – 2N6306, 2N6307
  = 12 - 60 – 2N6308
- Low Collector-Emitter Saturation Voltage @ I_C = 3.0 Adc
  $V_{CE(sat)}$ = 0.8 Vdc (Max) – 2N6306
  = 1.0 Vdc (Max) – 2N6307
  = 1.5 Vdc (Max) – 2N6308
- Current Gain Bandwidth Product –
  f_T = 5.0 MHz (Min) @ I_C = 0.3 Adc

8 AMPERE POWER TRANSISTORS NPN SILICON

250-300-350 VOLTS
125 WATTS

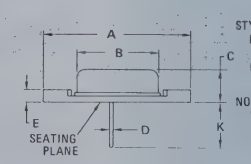


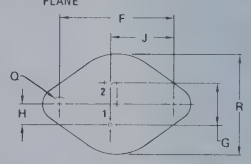
***MAXIMUM RATINGS**

Rating	Symbol	2N6306	2N6307	2N6308	Unit
Collector-Base Voltage	V_{CB}	500	600	700	Vdc
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Emitter-Base Voltage	V_{EB}	← 8.0 →			Vdc
Collector Current – Continuous Peak	I_C	← 8.0 → 16			Adc
Base Current	I_B	← 4.0 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 125 0.714 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.4	°C/W

*Indicates JEDEC Registered Data.

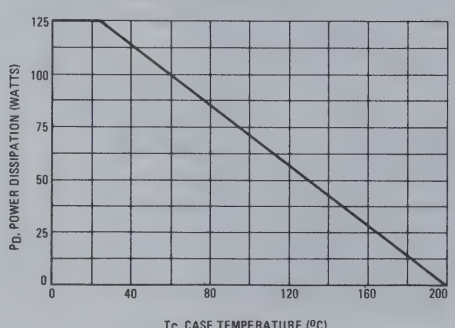




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

FIGURE 1 – POWER DERATING



***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N6306		250	–	
	2N6307		300	–	
	2N6308		350	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = Rated V_{CEO}, I_B = 0)			–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 500 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6306		–	0.5	
(V_{CE} = 600 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6307		–	0.5	
(V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6308		–	0.5	
(V_{CE} = 450 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6306		–	2.5	
(V_{CE} = 550 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6307		–	2.5	
(V_{CE} = 650 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6308		–	2.5	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 8.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	2N6306, 2N6307		15	75	
	2N6308		12	60	
(I_C = 8.0 Adc, V_{CE} = 5.0 Vdc)	2N6306, 2N6307		4.0	–	
	2N6308		3.0	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.6 Adc)	2N6306		–	0.8	
	2N6307		–	1.0	
	2N6308		–	1.5	
(I_C = 8.0 Adc, I_B = 2.0 Adc)	2N6306, 2N6307		–	5.0	
(I_C = 8.0 Adc, I_B = 2.67 Adc)	2N6308		–	5.0	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 2.0 Adc)	2N6306, 2N6307		–	2.3	
(I_C = 8.0 Adc, I_B = 2.67 Adc)	2N6308		–	2.5	
Base-Emitter On Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	2N6306, 2N6307		–	1.3	
	2N6308		–	1.5	
Second Breakdown Energy (Figure 2)		$E_{s/b}$			mJ
($I_{C(PK)}$ = 3.0 Adc, L = 40 mH, R_{BE} = 3 kΩ, V_{BB2} = 1.5 Vdc)			–	180	
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product (2)		f_T			MHz
(I_C = 0.3 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			5.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	250	
SWITCHING CHARACTERISTICS					
Rise Time		t_r			μs
(V_{CC} = 125 Vdc, I_C = 3.0 Adc, I_B = 0.6 Adc)			–	0.6	
Storage Time (3)		t_s			μs
(V_{CC} = 125 Vdc, I_C = 3.0 Adc, I_{B1} = 0.6 Adc, I_{B2} = 1.5 Adc)					
Pulse Width = 25 μs			–	1.6	
Pulse Width = 5.0 μs			–	0.8	
Fall Time		t_f			μs
(V_{CC} = 125 Vdc, I_C = 3.0 Adc, I_{B1} = 0.6 Adc, I_{B2} = 1.5 Adc)			–	0.4	

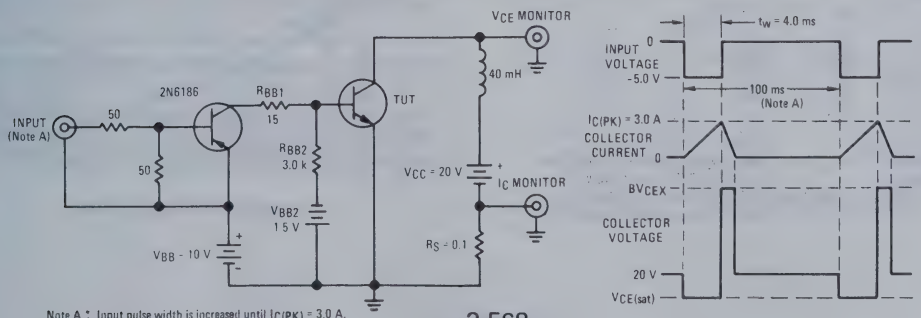
(1) Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle = 2.0%

(2) $f_T = |h_{fe}| \cdot f_{test}$

(3) "On" time is 25 μs. t_s decreases with shorter pulse widths, being approximately 50% of the values shown at a 5.0 μs pulse width.

*Indicates JEDEC Registered Data.

FIGURE 2 – SECOND BREAKDOWN ENERGY TEST CIRCUIT AND WAVEFORMS



Note A: Input pulse width is increased until $I_{C(PK)}$ = 3.0 A.

FIGURE 3 – THERMAL RESPONSE

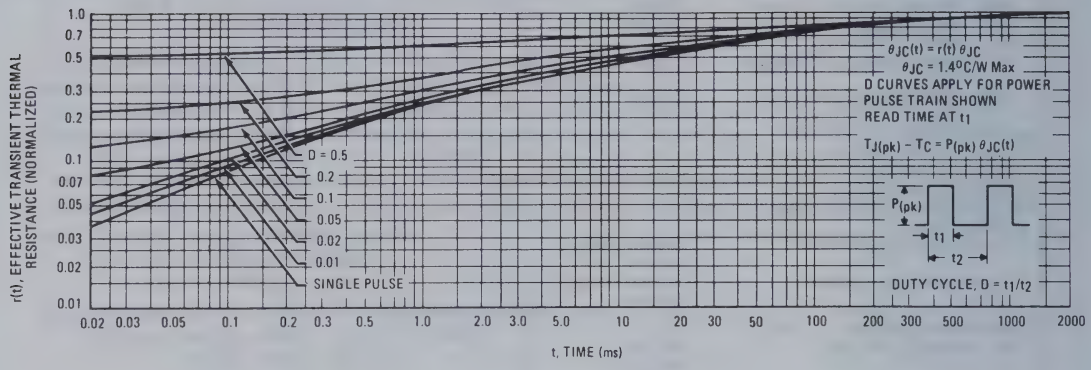
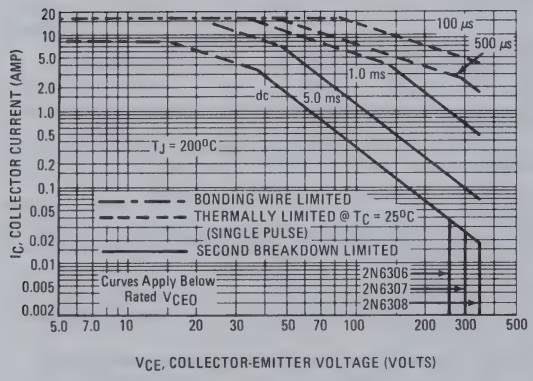


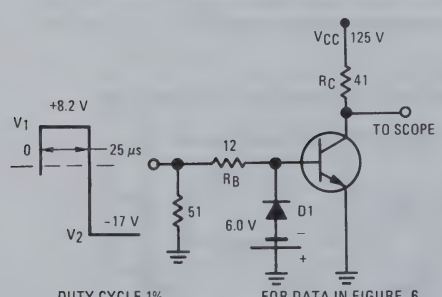
FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 3. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 5 – SWITCHING TIMES TEST CIRCUIT



DUTY CYCLE 1%
t_r, $t_f \leqslant 10$ ns
D_1 – 1N3879
COLLECTOR-BASE JUNCTION

FOR DATA IN FIGURE 6, R_B & R_C ARE VARIED TO OBTAIN DESIRED TEST CONDITIONS. D_1 OMITTED AND V_2 REDUCED TO 5.0 V FOR t_d and t_r MEASUREMENTS

FIGURE 6 – TURN-ON AND TURN-OFF TIMES

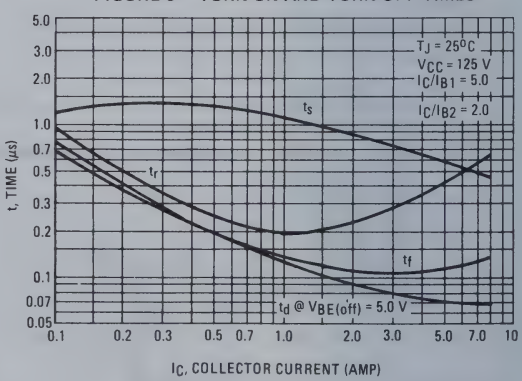


FIGURE 7 – DC CURRENT GAIN

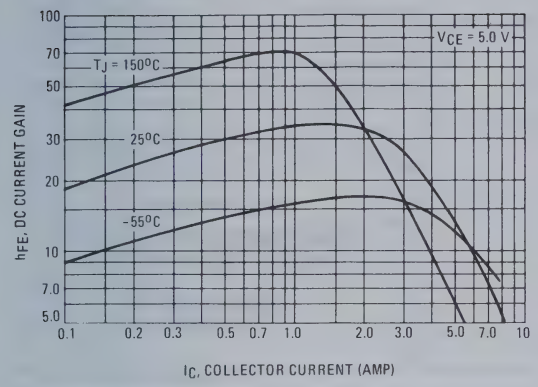


FIGURE 8 – COLLECTOR SATURATION REGION

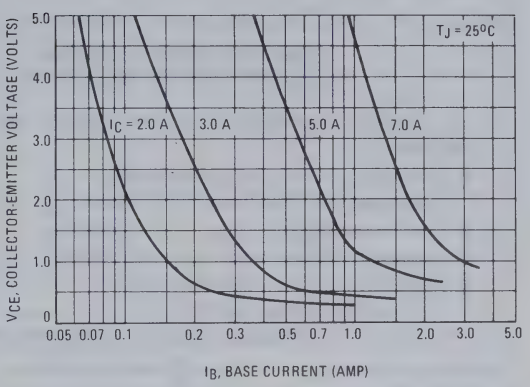


FIGURE 9 – "ON" VOLTAGES

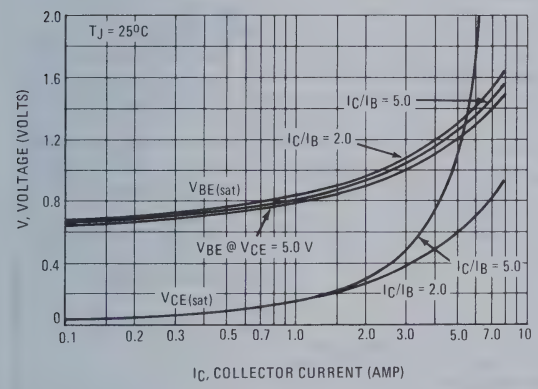


FIGURE 10 – TEMPERATURE COEFFICIENTS

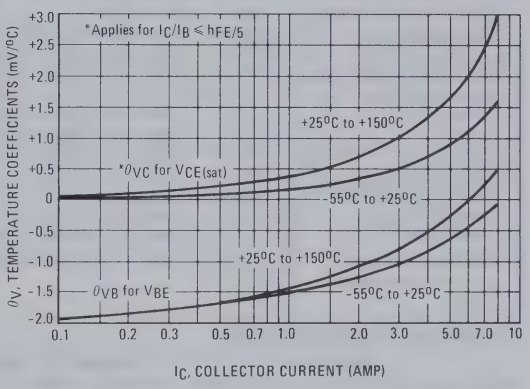


FIGURE 11 – COLLECTOR-CUTOFF REGION

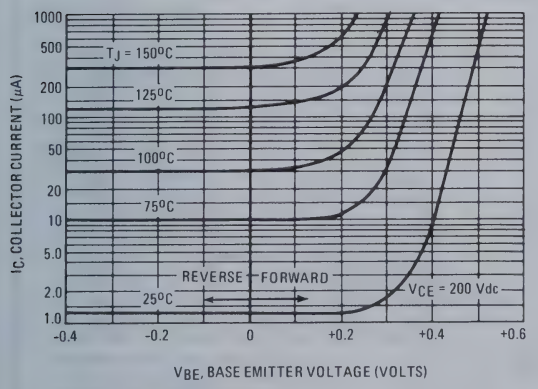
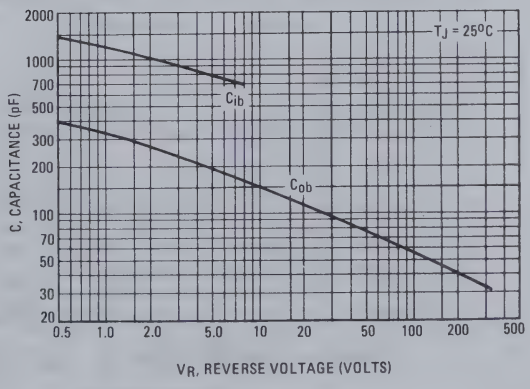


FIGURE 12 – CAPACITANCE



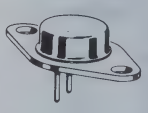
2N6312 thru 2N6314 PNP (SILICON)
2N4231A thru 2N4233A NPN

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.5 Adc
- Low Leakage Current — I_{CEX} = 0.1 mAdc (Max)
- Excellent DC Current Gain — h_{FE} = 25-100 @ I_C = 1.5 Adc
- High Current Gain — Bandwidth Product — f_T = 4.0 MHz @ I_C = 0.25 Adc
- Aluminum TO-66 Package for Better Power Handling Capability

5.0 AMPERE
COMPLEMENTARY SILICON POWER TRANSISTORS
40-60-80 VOLTS
75 WATTS



*MAXIMUM RATINGS

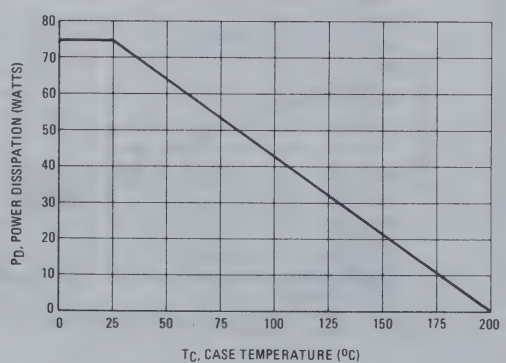
Rating	Symbol	2N4231A 2N6312	2N4232A 2N6313	2N4233A 2N6314	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous Peak	I_C	← 5.0 → ← 10 →			Adc
Base Current	I_B	← 2.0 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 75 → ← 0.43 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

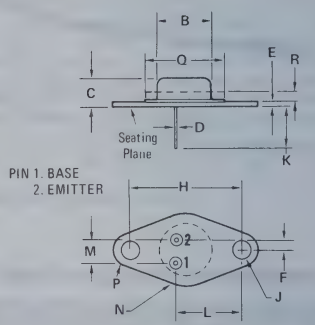
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.32	°C/W

*Indicates JEDEC registered data. (All values meet or exceed JEDEC registered data).

FIGURE 1 — POWER DERATING





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
B	.470	.500	11.94	12.70
C	.250	.340	6.35	8.64
D	.028	.034	.711	.864
E	.050	.075	1.27	1.91
F	.093	.107	2.36	2.72
H	.958	.962	24.33	24.43
J	.142	.152	3.61	3.86
K	.360	–	9.14	–
L	.570	.590	14.48	14.99
M	.190	.210	4.83	5.33
N	–	.350	–	8.89
P	–	.145	–	3.68
Q	–	.620	–	15.75
R	–	.050	–	1.27

All JEDEC dimensions and notes apply

CASE 80-02
TO-66

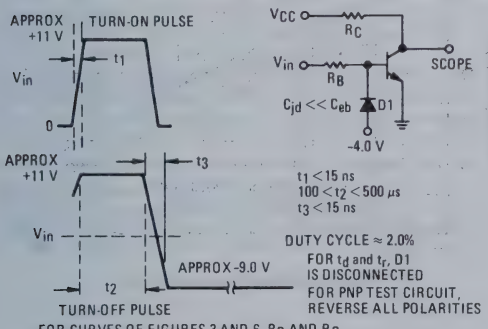
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N4231A, 2N6312		40	–	
	2N4232A, 2N6313		60	–	
	2N4233A, 2N6314		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N4231A, 2N6312		–	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N4232A, 2N6313		–	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N4233A, 2N6314		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4231A, 2N6312		–	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4232A, 2N6313		–	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4233A, 2N6314		–	0.1	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4231A, 2N6312		–	1.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4232A, 2N6313		–	1.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4233A, 2N6314		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N4231A, 2N6312		–	0.05	
(V_{CB} = 60 Vdc, I_E = 0)	2N4232A, 2N6313		–	0.05	
(V_{CB} = 80 Vdc, I_E = 0)	2N4233A, 2N6314		–	0.05	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)			–	0.5	
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
*(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			40	–	
*(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			25	100	
*(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			10	–	
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)			4.0	–	
*Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			–	0.7	
(I_C = 3.0 Adc, I_B = 0.3 Adc)			–	2.0	
(I_C = 5.0 Adc, I_B = 1.25 Adc)			–	4.0	
*Base-Emitter On Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			–	1.4	
***DYNAMIC CHARACTERISTICS**					
Current-Gain – Bandwidth Product		f_T			MHz
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)			4.0	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	300	
Small-Signal Current Gain		h_{fe}			–
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			20	–	

*Indicates JEDEC registered data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 AND 6, R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FIGURE 3 – TURN "ON" TIME

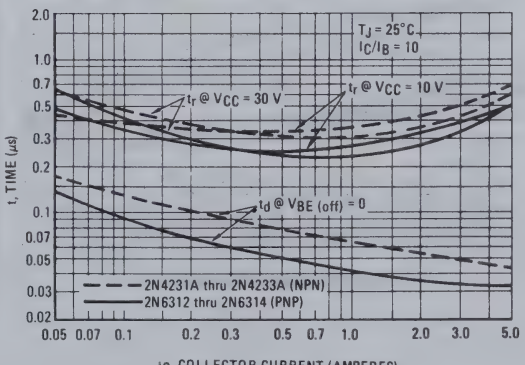


FIGURE 4 – THERMAL RESPONSE

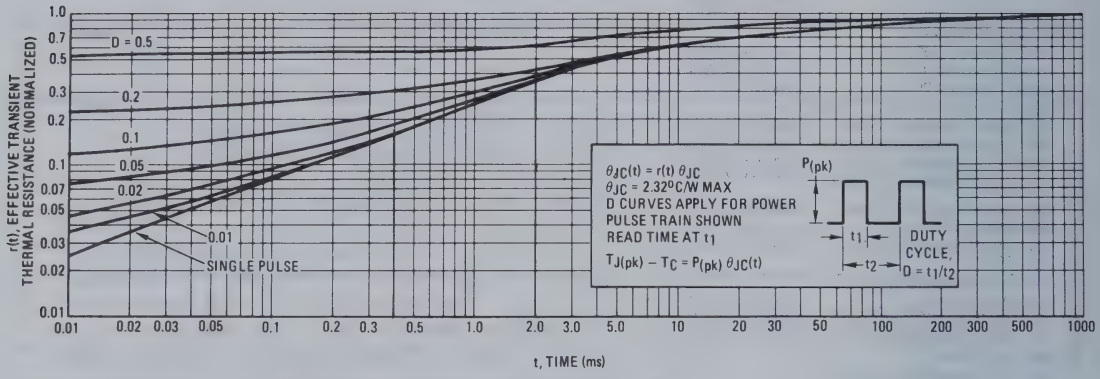
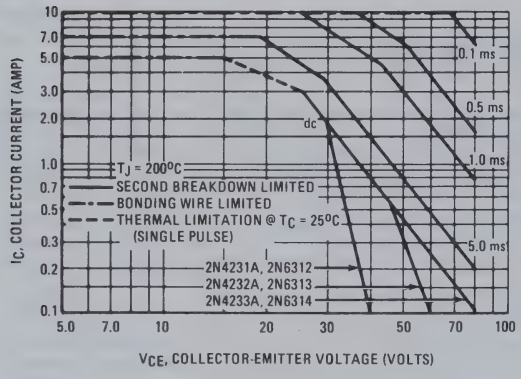


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415).

FIGURE 6 – TURN "OFF" TIME

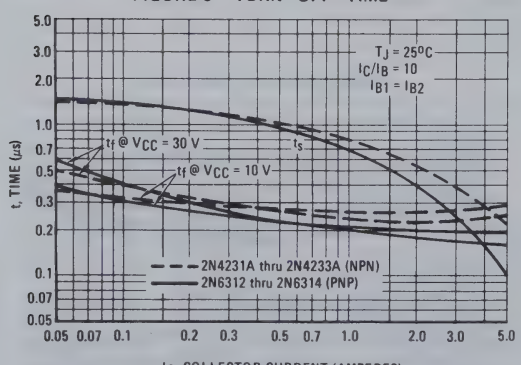
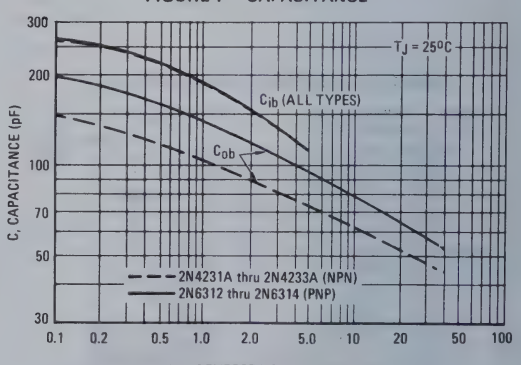


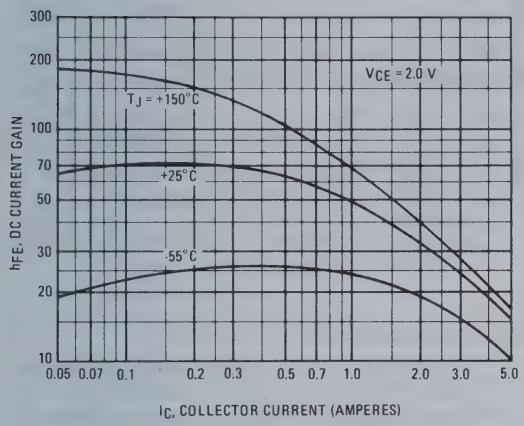
FIGURE 7 – CAPACITANCE



NPN
2N4231A thru 2N4233A

PNP
2N6312 thru 2N6314

FIGURE 8 – DC CURRENT GAIN



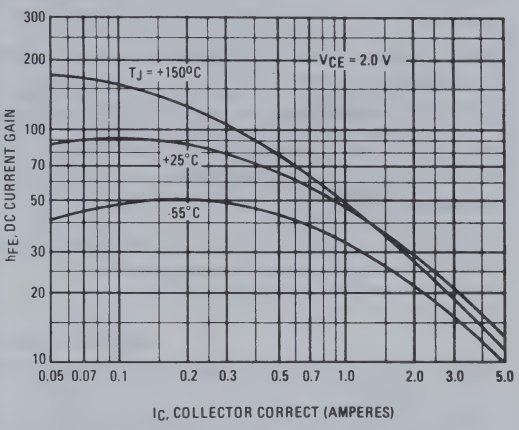
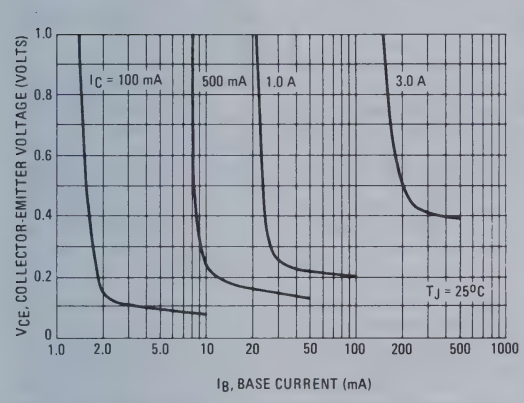


FIGURE 9 – COLLECTOR SATURATION REGION



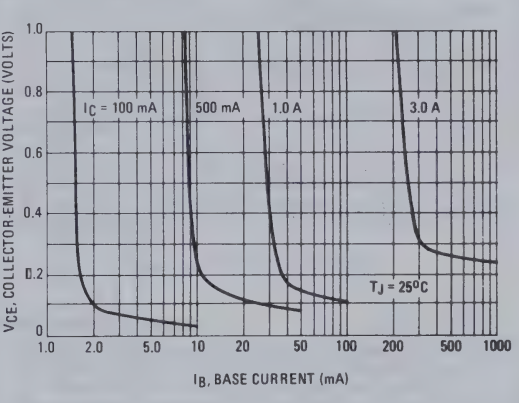
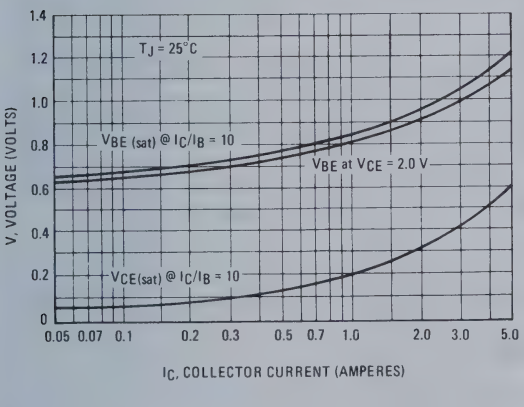
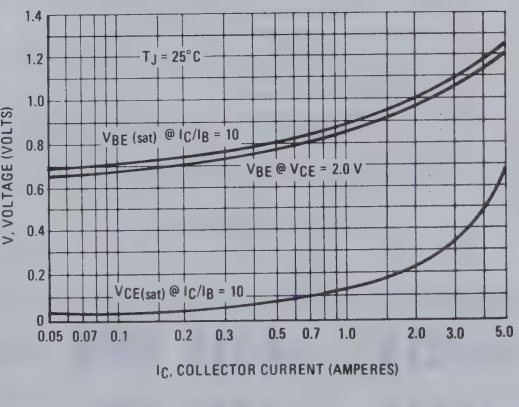


FIGURE 10 – "ON" VOLTAGES NPN PNP

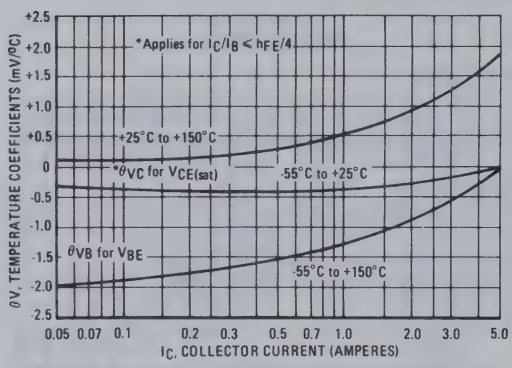




NPN
2N4231A thru 2N4233A

PNP
2N6312 thru 2N6314

FIGURE 11 – TEMPERATURE COEFFICIENTS



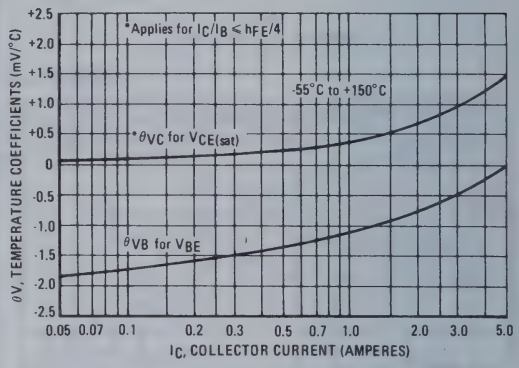
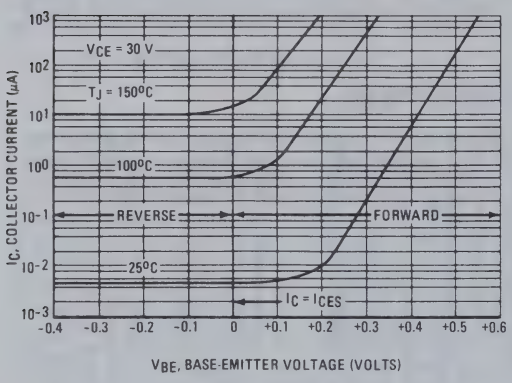


FIGURE 12 – COLLECTOR CUT-OFF REGION



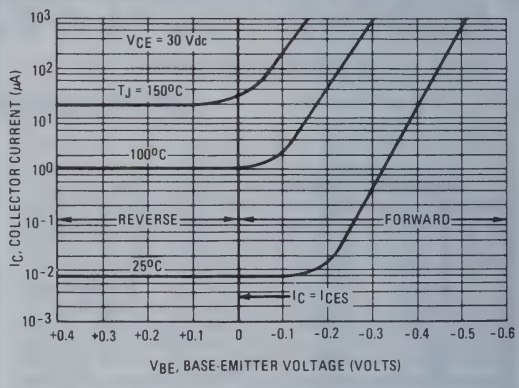
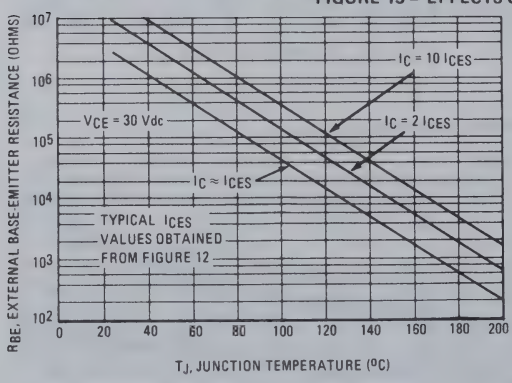
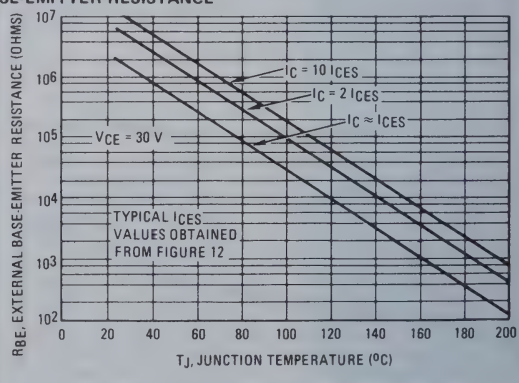


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE





2N6315, 2N6316 NPN (SILICON)
2N6317, 2N6318 PNP

For Specifications, See 2N5871 Data.

2N6338 (SILICON)
thru
2N6341

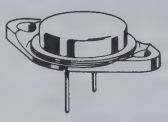
HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) – 2N6338
  = 120 Vdc (Min) – 2N6339
  = 140 Vdc (Min) – 2N6340
  = 150 Vdc (Min) – 2N6341
- High DC Current Gain –
  h_{FE} = 30-120 @ I_C = 10 Adc
  = 12 (Min) @ I_C = 25 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 Adc
- Fast Switching Times @ I_C = 10 Adc
  t_r = 0.3 μs (Max)
  t_s = 1.0 μs (Max)
  t_f = 0.25 μs (Max)
- Hard Solder Construction

25 AMPERE POWER TRANSISTORS NPN SILICON

100, 120, 140, 150 VOLTS
200 WATTS



*MAXIMUM RATINGS

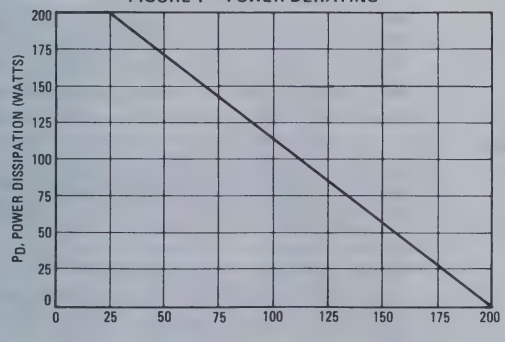
Rating	Symbol	2N6338	2N6339	2N6340	2N6341	Unit
Collector-Base Voltage	V_{CB}	120	140	160	180	Vdc
Collector-Emitter Voltage	V_{CEO}	100	120	140	150	Vdc
Emitter-Base Voltage	V_{EB}	6.0				Vdc
Collector Current – Continuous Peak	I_C	25 50				Adc
Base Current	I_B	10				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14				Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200				°C

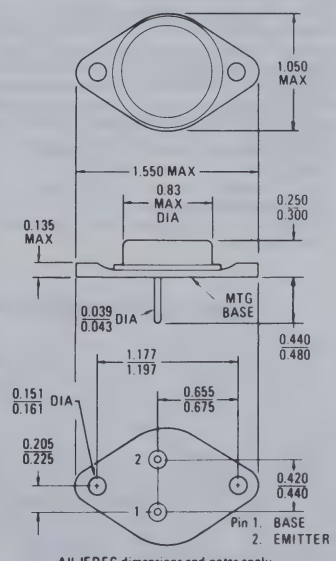
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

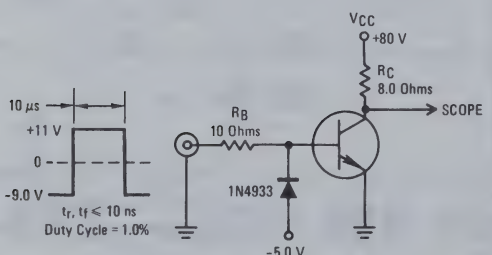
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6338		100	–	
	2N6339		120	–	
	2N6340		140	–	
	2N6341		150	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6338		–	50	
(V_{CE} = 60 Vdc, I_B = 0)	2N6339		–	50	
(V_{CE} = 70 Vdc, I_B = 0)	2N6340		–	50	
(V_{CE} = 75 Vdc, I_B = 0)	2N6341		–	50	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			–	10	μAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	1.0	mAdc
Collector Cutoff Current		I_{CBO}	–	10	μAdc
(V_{CB} = Rated V_{CB}, I_E = 0)					
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{BE} = 6.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			50	–	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)			30	120	
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			12	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			–	1.0	
(I_C = 25 Adc, I_B = 2.5 Adc)			–	1.8	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			–	1.8	
(I_C = 25 Adc, I_B = 2.5 Adc)			–	2.5	
Base-Emitter On Voltage		$V_{BE(on)}$	–	1.8	Vdc
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (2)		f_T	40	–	MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)					
Output Capacitance		C_{ob}	–	300	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
SWITCHING CHARACTERISTICS					
Rise Time		t_r	–	0.3	μs
($V_{CC} \approx$ 80 Vdc, I_C = 10 Adc, I_{B1} = 1.0 Adc, $V_{BE(off)}$ = 6.0 Vdc)					
Storage Time		t_s	–	1.0	μs
($V_{CC} \approx$ 80 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)					
Fall Time		t_f	–	0.25	μs
($V_{CC} \approx$ 80 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)					

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



Note: For information on Figures 3 and 6, R_B and R_C were varied to obtain desired test conditions.

FIGURE 3 – TURN-ON TIME

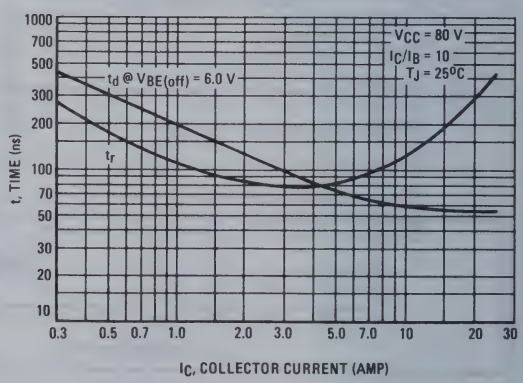


FIGURE 4 – THERMAL RESPONSE

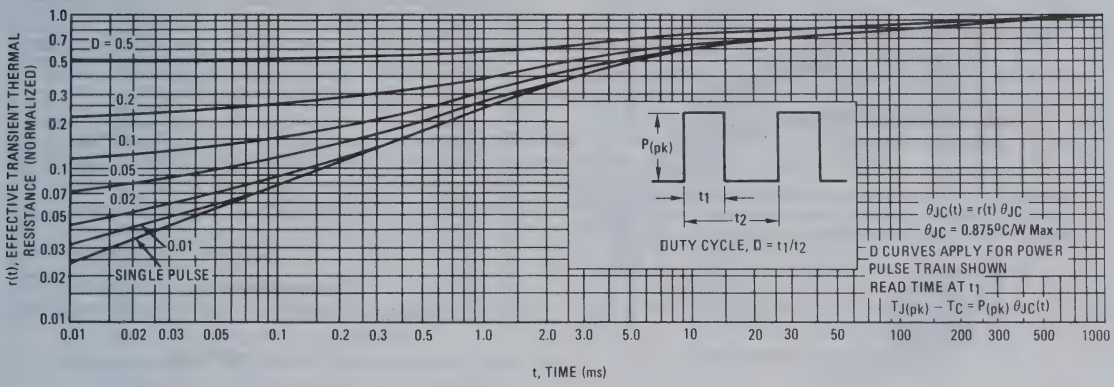
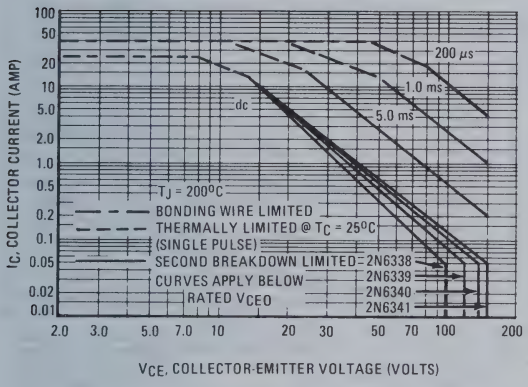


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

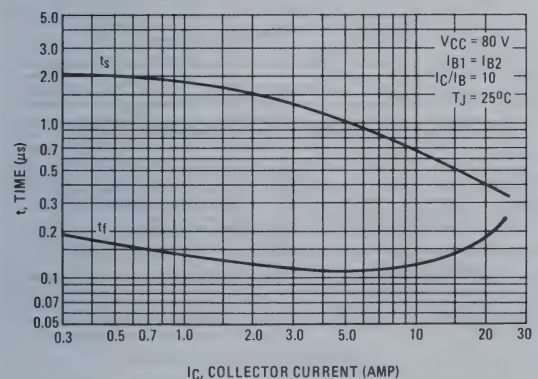


FIGURE 7 – CAPACITANCE

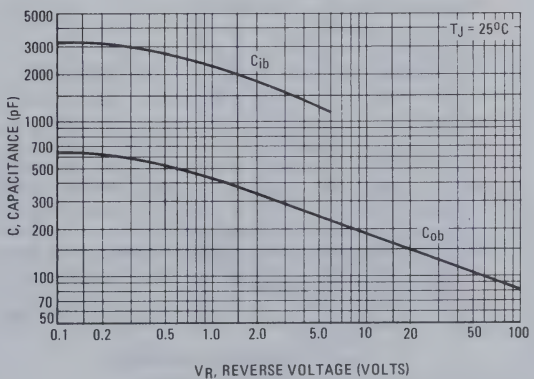


FIGURE 8 – DC CURRENT GAIN

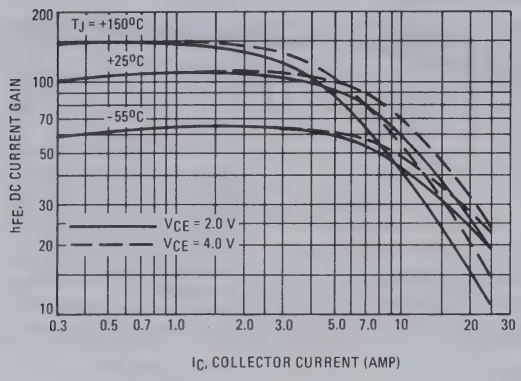


FIGURE 9 – COLLECTOR SATURATION REGION

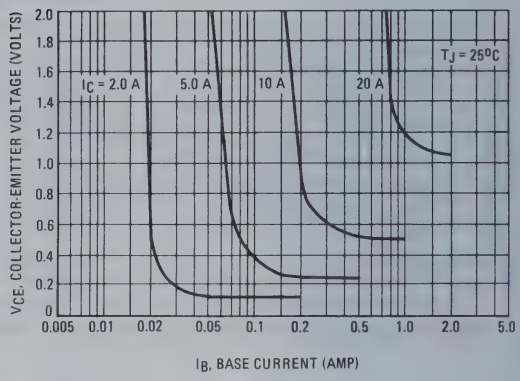


FIGURE 10 – "ON" VOLTAGES

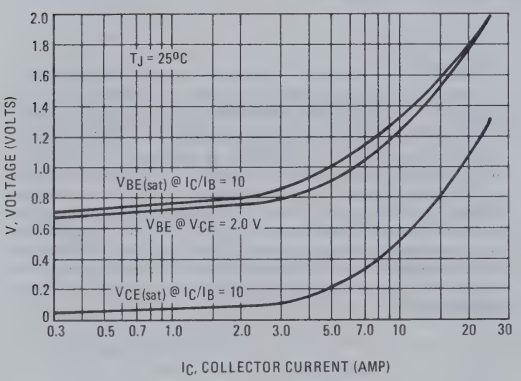


FIGURE 11 – TEMPERATURE COEFFICIENTS

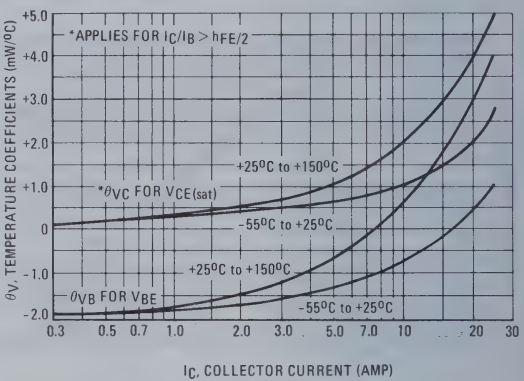


FIGURE 12 – COLLECTOR CUT-OFF REGION

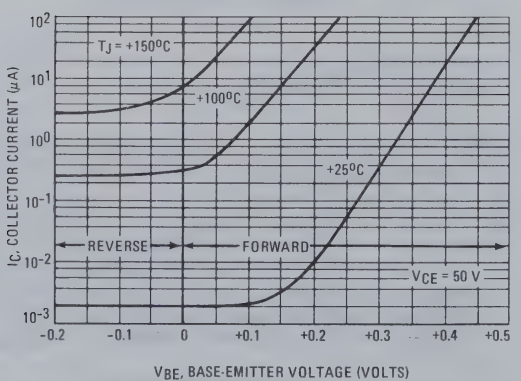
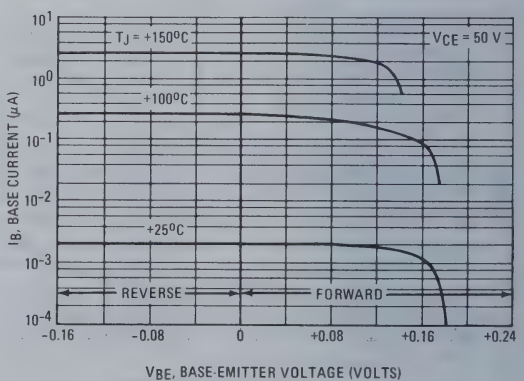


FIGURE 13 – BASE CUT-OFF REGION



2N6342 (SILICON)
thru
2N6349

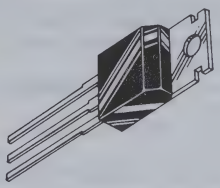


SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Blocking Voltage to 800 Volts
- All Diffused and Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermowatt Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Gate Triggering Guaranteed in Two Modes (2N6342, 2N6343, 2N6344, 2N6345) or Four Modes (2N6346, 2N6347, 2N6348, 2N6349)
- For 400 Hz Operation, Consult Factory
- 12 Ampere Devices Available as 2N6342A thru 2N6349A

TRIACS (THYRISTORS) 8 AMPERES RMS 200-800 VOLTS



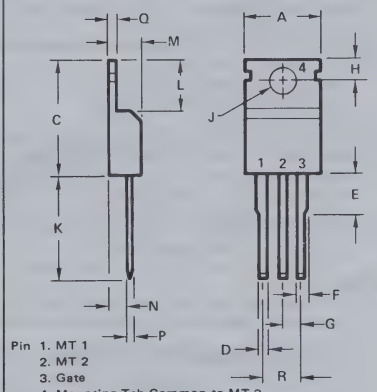
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
* Repetitive Peak Off-State Voltage, Note 1 (T_J = -40 to +100°C) ½ Sine Wave 50 to 60 Hz, Gate Open	V_{DRM}		Volts
2N6342, 2N6346		200	
2N6343, 2N6347		400	
2N6344, 2N6348		600	
2N6345, 2N6349		800	
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (T_C = +80°C) Full Cycle Sine Wave 50 to 60 Hz (T_C = +90°C)	$I_{T(RMS)}$	8.0 4.0	Amp
*Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_J = +80°C) preceded and followed by 10 Rated Current	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power (T_C = +80°C, Pulse Width = 2.0 μs)	P_{GM}	20	Watts
*Average Gate Power (T_C = +80°C, t = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
* Thermal Resistance, Junction to Case	$R\theta_{JC}$	2.2	°C/W

*Indicates JEDEC Registered Data.



Pin 1. MT 1
2. MT 2
3. Gate
4. Mounting Tab Common to MT 2

All JEDEC dimensions and notes apply

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.380	0.420	9.660	10.66
C	0.560	0.625	14.23	15.87
D	0.020	0.045	0.510	1.140
E		0.250		6.350
F	0.045	0.070	1.140	1.770
G	0.090	0.110	2.290	2.790
H	0.100	0.120	2.540	3.040
J	0.139	0.147	3.531	3.733
K	0.500	0.562	12.70	14.27
L	0.230	0.270	5.850	6.820
M	0.140	0.190	3.560	4.820
N	0.080	0.115	2.040	2.920
P	0.012	0.045	0.310	1.140
Q	0.020	0.055	0.510	1.390
R	0.190	0.210	4.830	5.330

CASE 221-02
TO 220 AB

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

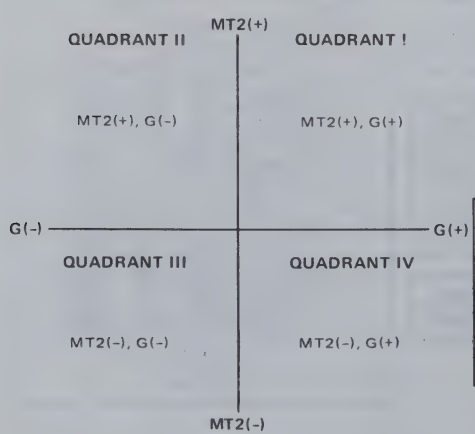
Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
*Peak On-State Voltage (Either Direction) I_{TM} = 11 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0 %	V_{TM}	–	1.3	1.55	Volts
Peak Gate Trigger Current Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GTM}				mA
MT2 (+), G(+) All Types		–	6.0	50	
MT2 (+), G(–) 2N6346 thru 2N6349		–	6.0	75	
MT2 (–), G(–) All Types		–	10	50	
MT2 (–), G(+) 2N6346 thru 2N6349		–	25	75	
*MT2 (+), G(+); MT2 (–), G(–) T_C = -40°C All Types		–	–	100	
*MT2 (+), G(–); MT2 (–), G(+) T_C = -40°C 2N6346 thru 2N6349		–	–	125	
Peak Gate Trigger Voltage Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GTM}				Volts
MT2 (+), G(+) All Types		–	0.9	2.0	
MT2 (+), G(–) 2N6346 thru 2N6349		–	0.9	2.5	
MT2 (–), G(–) All Types		–	1.1	2.0	
MT2 (–), G(+) 2N6346 thru 2N6349		–	1.4	2.5	
*MT2 (+), G(+); MT2 (–), G(–) T_C = -40°C All Types		–	–	2.5	
*MT2 (+), G(–); MT2 (–), G(+) T_C = -40°C 2N6346 thru 2N6349		–	–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 100°C					
*MT2 (+), G(+); MT2 (–), G(–) All Types		0.2	–	–	
*MT2 (+), G(–); MT2 (–), G(–) 2N6346 thru 2N6349		0.2	–	–	
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 200 mA — T_C = 25°C	I_H	–	6.0	40	mA
— T_C = -40°C		–	–	75*	
*Turn-On Time Rated V_{DRM}, I_{TM} = 11 A, I_{GT} = 120 mA, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	tgt	–	1.5	2.0	μs
Critical Rate of Rise of Commutation Voltage Rated V_{DRM}, I_{TM} = 11 A, Commutating di/dt = 4.3 A/ms, Gate Unenergized, T_C = 80°C	dv/dt	–	5.0	–	V/μs

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

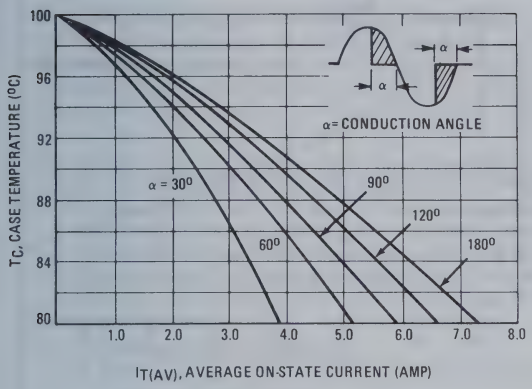


FIGURE 2 – RMS CURRENT DERATING

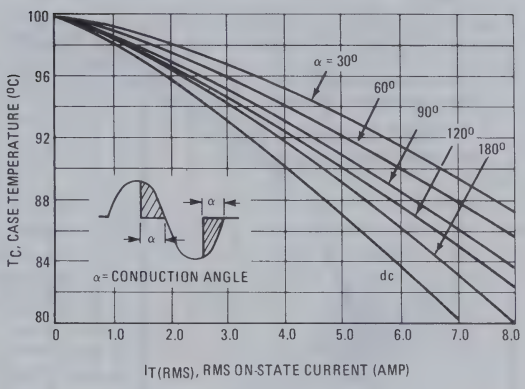


FIGURE 3 – ON-STATE POWER DISSIPATION

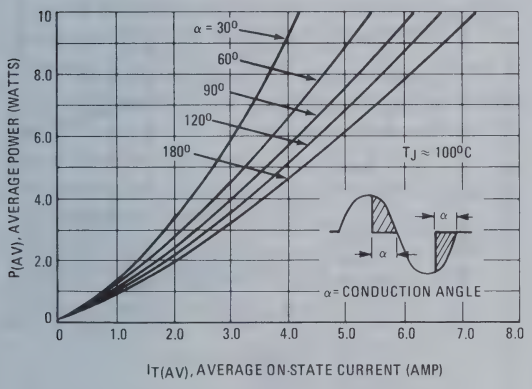


FIGURE 4 – ON-STATE POWER DISSIPATION

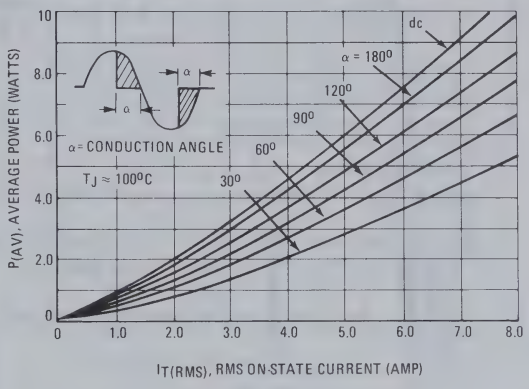


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

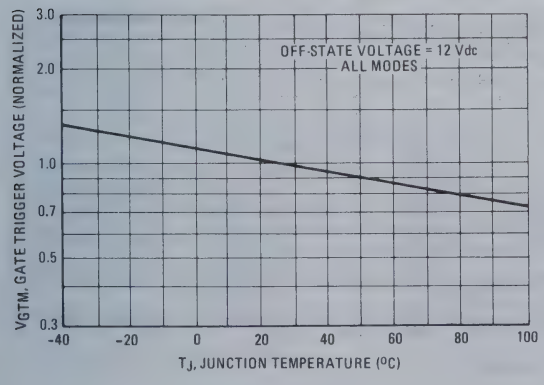


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

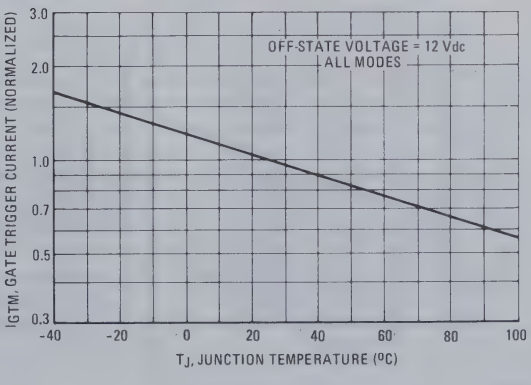


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

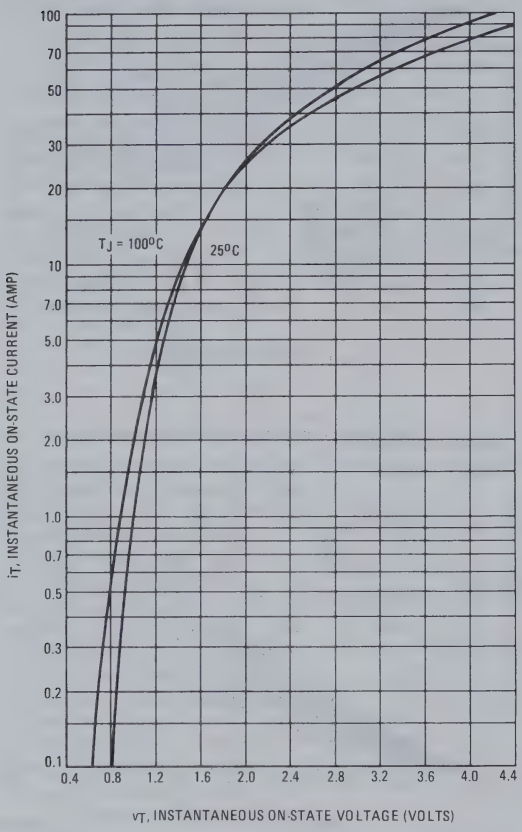


FIGURE 8 – TYPICAL HOLDING CURRENT

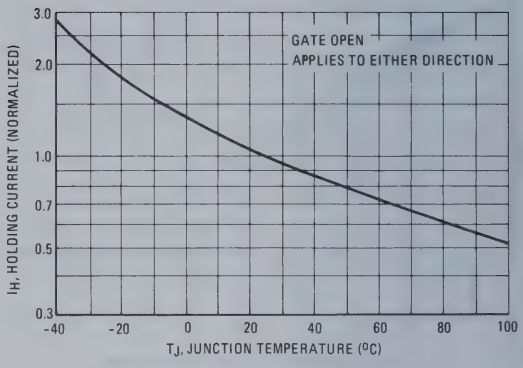


FIGURE 9 – MAXIMUM NON-REPETITIVE SURGE CURRENT

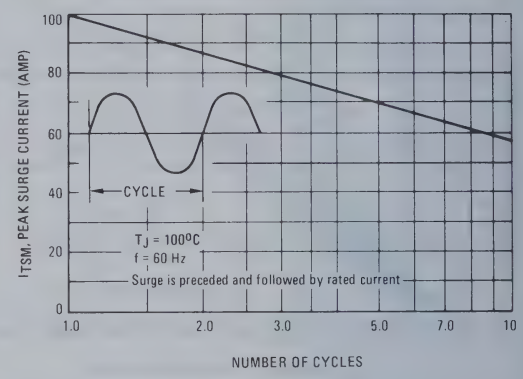
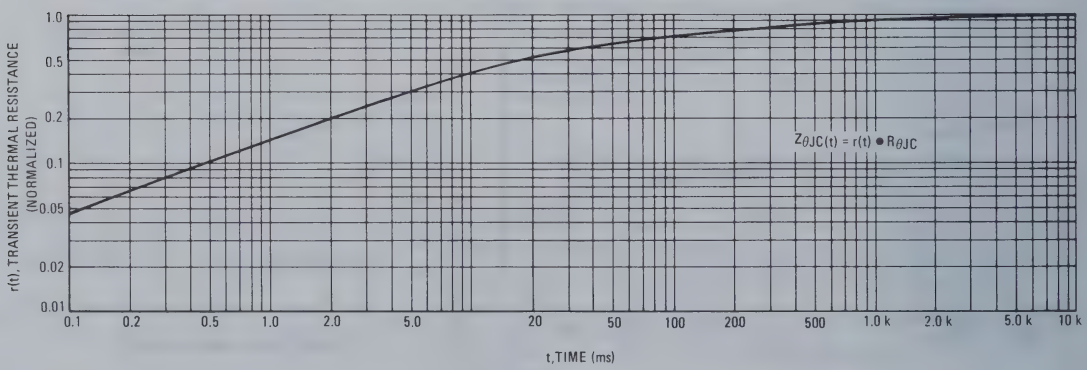


FIGURE 10 – THERMAL RESPONSE



2N6342A (SILICON)
thru
2N6349A

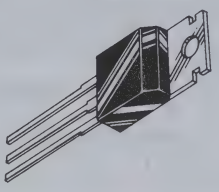


SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Blocking Voltage to 800 Volts
- All Diffused and Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermowatt Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Gate Triggering Guaranteed in Two Modes (2N6342A, 2N6343A, 2N6344A, 2N6345A) or Four Modes (2N6346A, 2N6347A, 2N6348A, 2N6349A)
- For 400 Hz Operation, Consult Factory
- 8 Ampere Devices Available as 2N6342 thru 2N6349

TRIACS (THYRISTORS)
12 AMPERES RMS
200 – 800 VOLTS



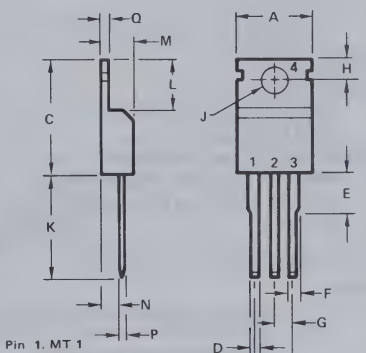
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Off-State Voltage, Note 1 (T_J = -40 to +110°C) ½ Sine Wave 50 to 60 Hz, Gate Open	V_{DRM}		Volts
2N6342A, 2N6346A		200	
2N6343A, 2N6347A		400	
2N6344A, 2N6348A		600	
2N6345A, 2N6349A		800	
*Peak Gate Voltage	V_{GM}	10	Volts
*On-State Current RMS (T_C = +80°C) Full Cycle Sine Wave 50 to 60 Hz (T_C = +95°C)	$I_{T(RMS)}$	12 6.0	Amp
*Peak Surge Current (One Full Cycle, 60 Hz, T_C = +80°C) preceded and followed by rated current	I_{TSM}	120	Amp
Circuit Fusing Considerations (T_J = -40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power (T_C = +80°C, Pulse Width = 2.0 μs	P_{GM}	20	Watts
*Average Gate Power (T_C = +80°C, t = 8.3 ms)	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
*Operating Junction Temperature Range	T_J	-40 to +110	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTIC

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	$R\theta_{JC}$	2.0	°C/W

*Indicates JEDEC Registered Data.



Pin 1. MT 1
2. MT 2
3. Gate
4. Mounting Tab Common to MT 2

All JEDEC dimensions and notes apply

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.380	0.420	9.660	10.66
C	0.560	0.625	14.23	15.87
D	0.020	0.045	0.510	1.140
E		0.250		6.350
F	0.045	0.070	1.140	1.770
G	0.090	0.110	2.290	2.790
H	0.100	0.120	2.540	3.040
J	0.139	0.147	3.531	3.733
K	0.500	0.562	12.70	14.27
L	0.230	0.270	5.850	6.820
M	0.140	0.190	3.560	4.820
N	0.080	0.115	2.040	2.920
P	0.012	0.045	0.310	1.140
Q	0.020	0.055	0.510	1.390
R	0.190	0.210	4.830	5.330

CASE 221-02
TO 220 AB

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

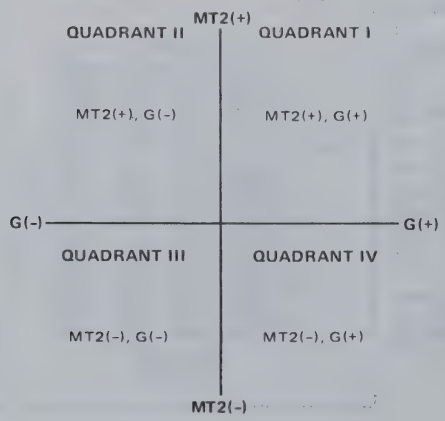
Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C, Gate Open	I_{DRM}	–	–	2.0	mA
*Peak On-State Voltage (Either Direction) I_{TM} = 17 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0 %	V_{TM}	–	1.3	1.75	Volts
Peak Gate Trigger Current Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GTM}				mA
MT2 (+), G(+) All Types		–	6.0	50	
MT2 (+), G(–) 2N6346A thru 2N6349A		–	6.0	75	
MT2 (–), G(–) All Types		–	10	50	
MT2 (–), G(+) 2N6346A thru 2N6349A		–	25	75	
*MT2 (+), G(+); MT2 (–), G(–) T_C = -40°C All Types		–	–	100	
*MT2 (+), G(–); MT2 (–), G(+) T_C = -40°C 2N6346A thru 2N6349A		–	–	125	
Peak Gate Trigger Voltage Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GTM}				Volts
MT2 (+), G(+) All Types		–	0.9	2.0	
MT2 (+), G(–) 2N6346A thru 2N6349A		–	0.9	2.5	
MT2 (–), G(–) All Types		–	1.1	2.0	
MT2 (–), G(+) 2N6346A thru 2N6349A		–	1.4	2.5	
*MT2 (+), G(+); MT2 (–), G(–) T_C = -40°C All Types		–	–	2.5	
*MT2 (+), G(–); MT2 (–), G(+) T_C = -40°C 2N6346A thru 2N6349A		–	–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 110°C					
*MT2 (+), G(+); MT2 (–), G(–) All Types		0.2	–	–	
*MT2 (+), G(–); MT2 (–), G(+) 2N6346A thru 2N6349A		0.2	–	–	
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 200 mA — T_C = 25°C	I_H	–	6.0	40	mA
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 200 mA — T_C = -40°C		–	–	75*	
*Turn-On Time Rated V_{DRM}, I_{TM} = 17A I_{GT} = 120 mA, Rise Time = 0.1 μs, Pulse Width = 2.0 μs	tgt	–	1.5	2.0	μs
Critical Rate of Rise of Commutation Voltage Rated V_{DRM}, I_{TM} = 17A, Commutating di/dt = 6.5 A/ms, Gate Unenergized T_C = 80°C	dv/dt	–	5.0	–	V/μs

*Indicates JEDEC Registered Data

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

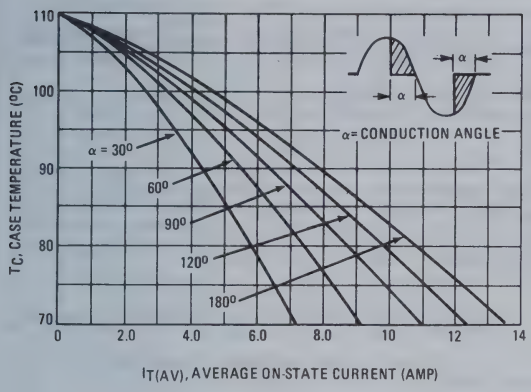


FIGURE 2 – RMS CURRENT DERATING

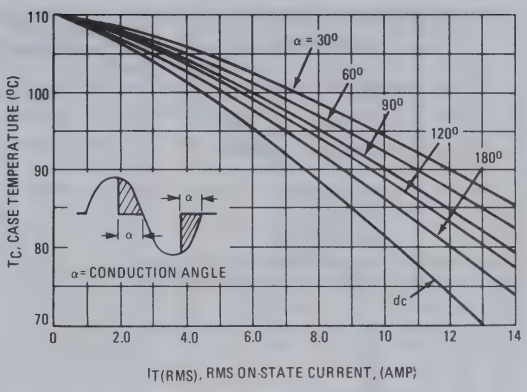


FIGURE 3 – ON-STATE POWER DISSIPATION

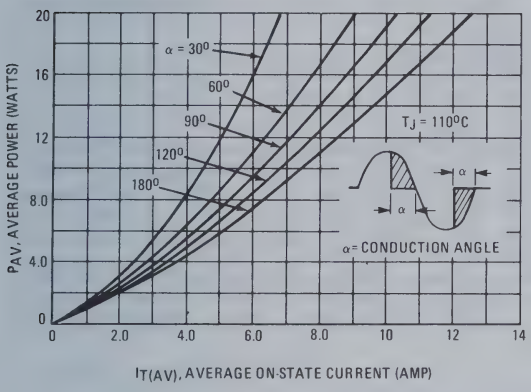


FIGURE 4 – ON-STATE POWER DISSIPATION

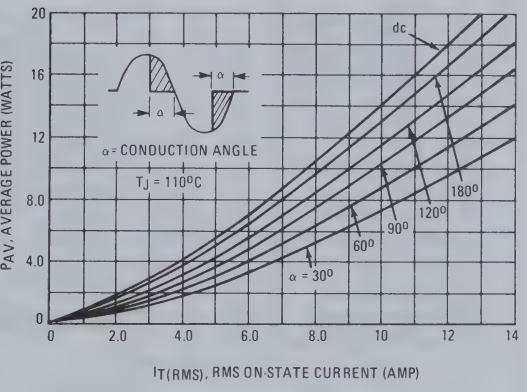


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

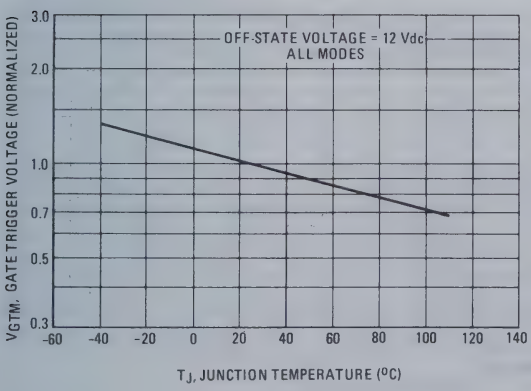


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

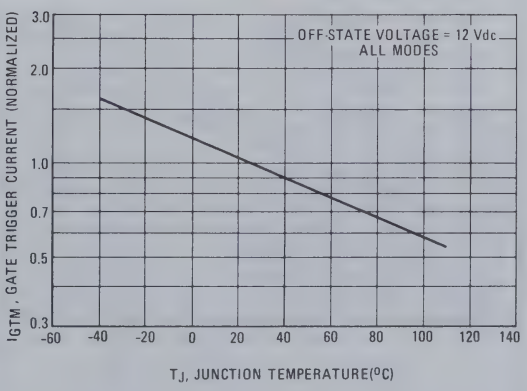


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

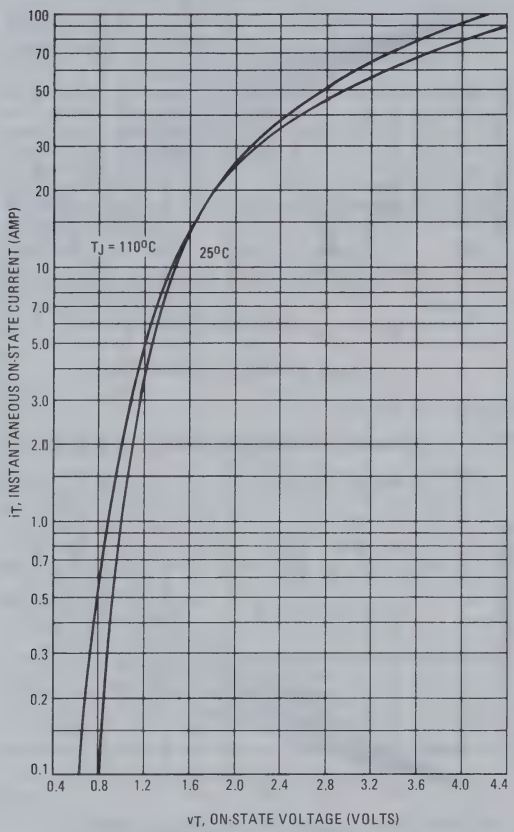


FIGURE 8 – TYPICAL HOLDING CURRENT

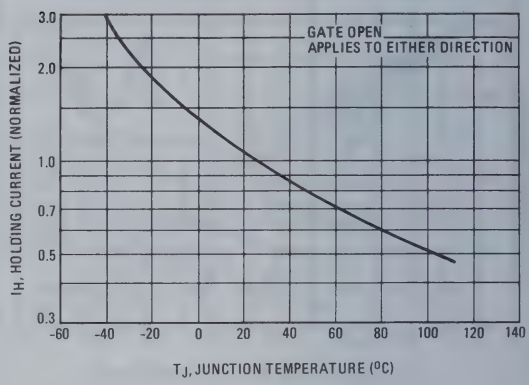


FIGURE 9 – MAXIMUM NON-REPETITIVE SURGE CURRENT

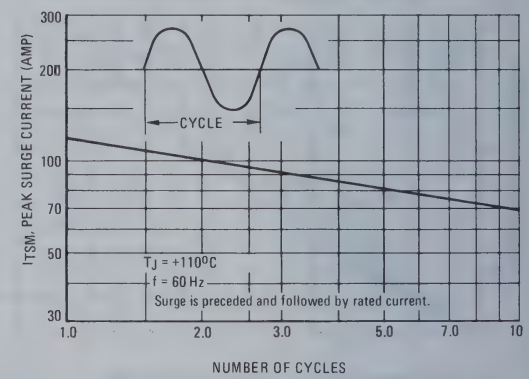
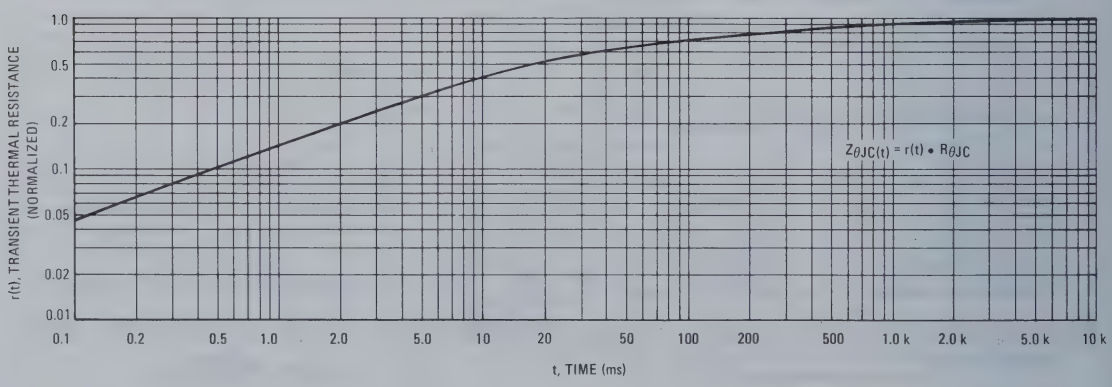


FIGURE 10 – THERMAL RESPONSE



2N6355 (SILICON)
thru
2N6358

NPN SILICON POWER DARLINGTON TRANSISTORS

Uni-Base (single-diffused) transistors designed for series pass regulators and power switching applications, audio amplifiers and for use in inductive power control circuitry.

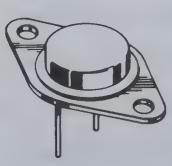
- High DC Current Gain –
  h_{FE} = 500-5000 @ I_C = 4.0 Adc – 2N6355, 2N6357
  = 1500-10,000 @ I_C = 4.0 Adc – 2N6356, 2N6358
  = 200 (Min) @ I_C = 10 Adc – 2N6355, 2N6357
  = 400 (Min) @ I_C = 10 Adc – 2N6356, 2N6358
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.8 Vdc (Max) @ I_C = 4.0 Adc
  = 2.4 Vdc (Max) @ I_C = 10 Adc
- High Second Breakdown Energy Capability –
  $I_{S/b}$ = 3.75 Adc @ V_{CE} = 40 Vdc – 2N6355, 2N6356
  = 2.0 Adc @ V_{CE} = 60 Vdc – 2N6357, 2N6358
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

UNI-BASE

DARLINGTON

20 AMPERE POWER TRANSISTORS

NPN SILICON
40, 60 VOLTS
150 WATTS



*MAXIMUM RATINGS

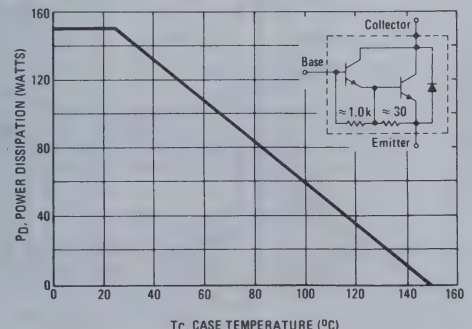
Rating	Symbol	2N6355 2N6356	2N6357 2N6358	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	50	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	20 30		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 1.20		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

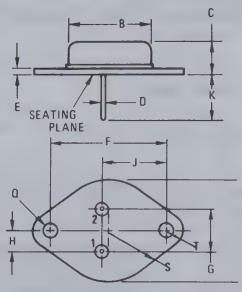
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.833	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING/SCHEMATIC





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0.188

All JEDEC dimensions and notes apply

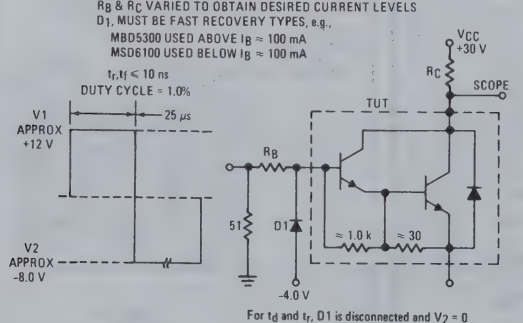
CASE 1-03
(TO-3)

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, I_B = 0)	2N6355, 2N6356	$V_{CEO(sus)}$	40	–	Vdc
	2N6357, 2N6358		60	–	
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	2N6355, 2N6356	I_{CEO}	–	5.0	mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6357, 2N6358		–	5.0	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6355, 2N6356	I_{CEX}	–	2.0	mAdc
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6357, 2N6358		–	2.0	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6355, 2N6356		–	10	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6357, 2N6358		–	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	2N6355, 2N6357	h_{FE}	500	5000	–
	2N6356, 2N6358		1500	10,000	
(I_C = 10 Adc, V_{CE} = 5.0 Vdc)	2N6355, 2N6357		200	–	
	2N6356, 2N6358		400	–	
(I_C = 20 Adc, V_{CE} = 5.0 Vdc)	2N6355, 2N6357		50	–	
	2N6356, 2N6358		100	–	
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 16 mAdc)		$V_{CE(sat)}$	–	1.8	Vdc
(I_C = 10 Adc, I_B = 100 mAdc)			–	2.4	
(I_C = 20 Adc, I_B = 1.0 Adc)			–	4.0	
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	–	3.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	3.0	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common-Emitter Small-Signal Short-Circuit Current Transfer Ratio (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f_{test} = 50 kHz)		$\|h_{fe}\|$	4.0	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	600	pF
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



For t_d and t_r, D1 is disconnected and V_2 = 0

FIGURE 3 – TURN-ON TIME

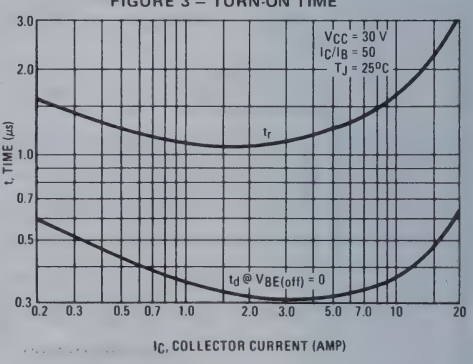


FIGURE 4 – THERMAL RESPONSE

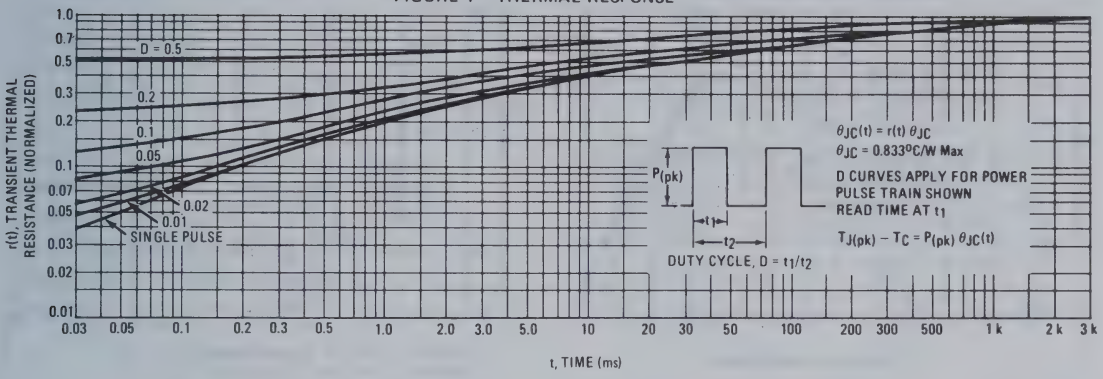
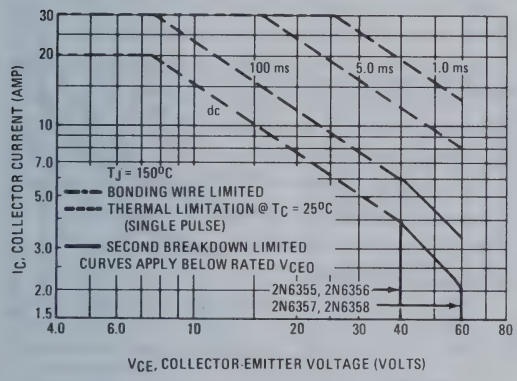


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

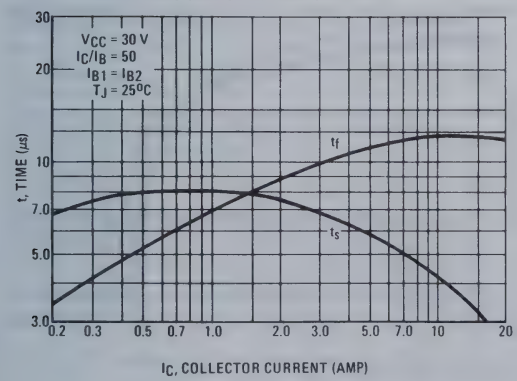


FIGURE 7 – CAPACITANCE

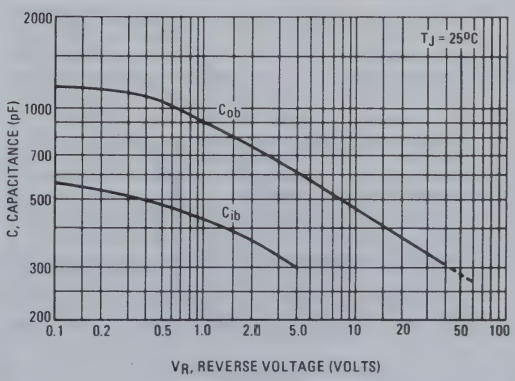


FIGURE 8 – DC CURRENT GAIN

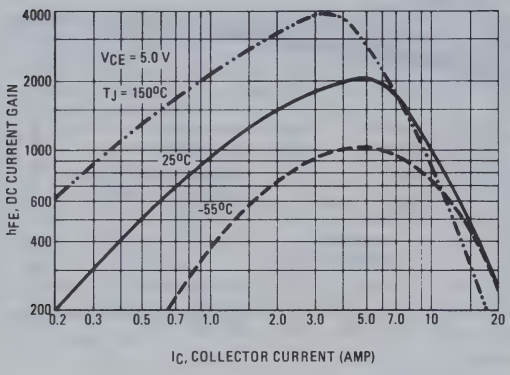


FIGURE 9 – COLLECTOR-SATURATION REGION

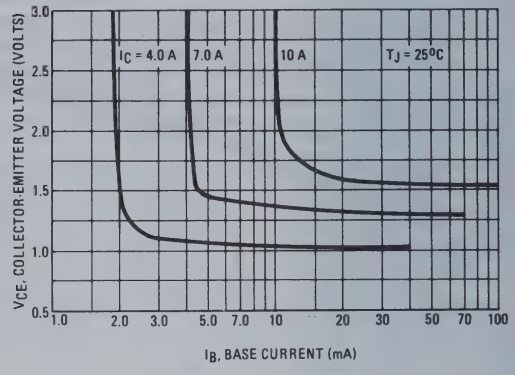


FIGURE 10 – "ON" VOLTAGES

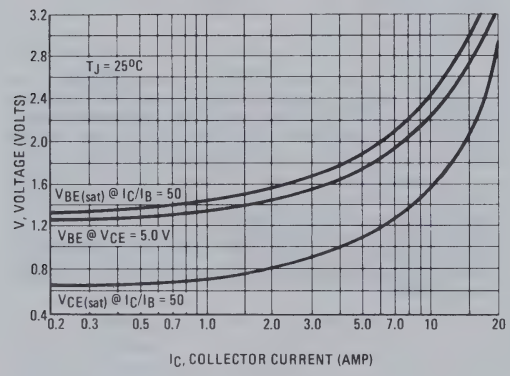


FIGURE 11 – TEMPERATURE COEFFICIENTS

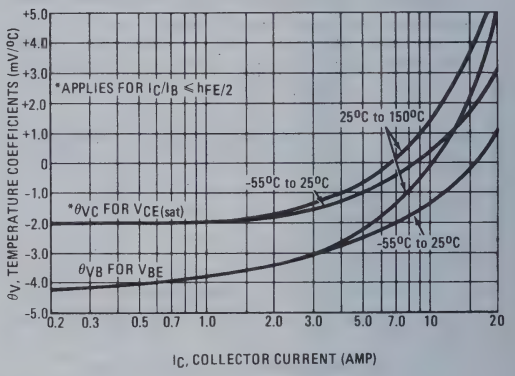


FIGURE 12 – COLLECTOR CUTOFF REGION

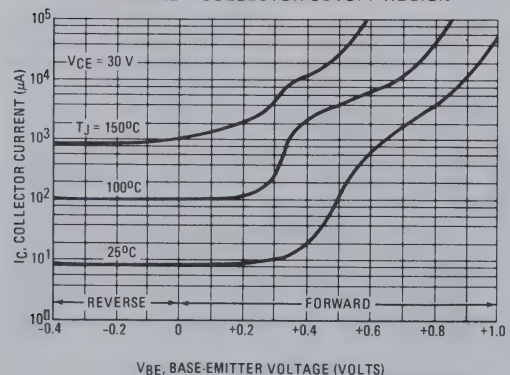
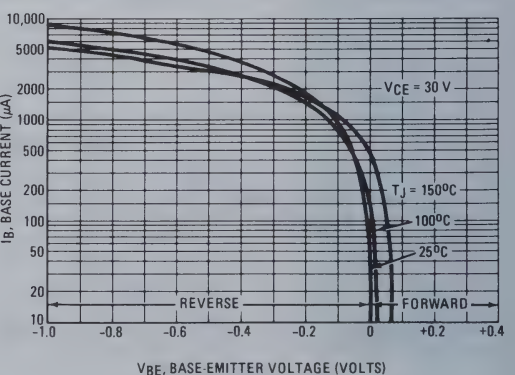


FIGURE 13 – BASE CUTOFF REGION



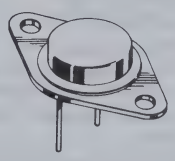
2N6359 (SILICON)
2N6360
2N4348

HIGH POWER NPN SILICON POWER TRANSISTORS

Uni-Base (single-diffused) transistors designed for audio amplifiers, series pass regulators, and inductive switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 80 Vdc (Min) — 2N6359
  = 100 Vdc (Min) — 2N6360
  = 120 Vdc (Min) — 2N4348
- DC Current Gain — h_{FE} = 15-60
  @ I_C = 8.0 Adc — 2N6359
  = 6.0 Adc — 2N6360
  = 5.0 Adc — 2N4348
- Second Breakdown Collector Current —
  $I_{S/b}$ = 3.75 Adc @ V_{CE} = 40 Vdc — 2N6359
  = 2.5 Adc @ V_{CE} = 60 Vdc — 2N6360
  = 1.5 Adc @ V_{CE} = 80 Vdc — 2N4348
- Second Breakdown Energy —
  $E_{S/b}$ = 125 mJ (Min) @ V_{BE} = 4.0 Vdc, I_C = 2.5 Adc

10, 12, 16 AMPERE POWER TRANSISTORS
NPN SILICON
80, 100, 120 VOLTS
120, 150 WATTS



*MAXIMUM RATINGS

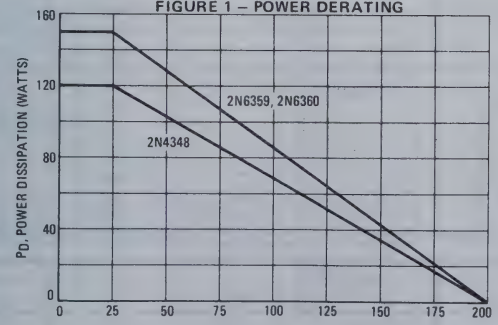
Rating	Symbol	2N6359	2N6360	2N4348	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	120	Vdc
Collector-Emitter Voltage	V_{CEX}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous Peak	I_C	16 30	12 30	10 30	A
Base Current — Continuous Peak	I_B	← 4.0 → ← 15 →			A
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.857		120 0.686	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

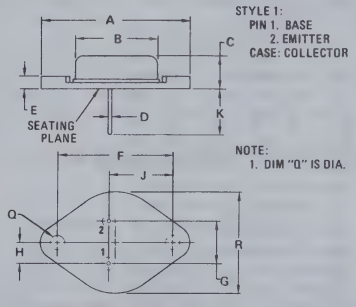
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N6359	2N6360	2N4348	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17		1.46	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

*** ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

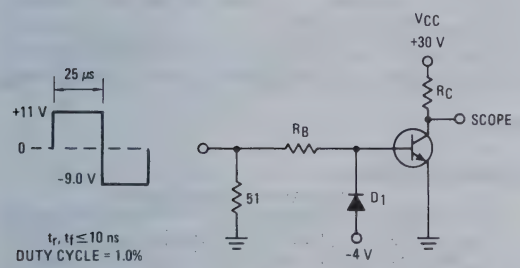
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	2N6359		80	–	
	2N6360		100	–	
	2N4348		120	–	
Collector-Emitter Sustaining Voltage		$V_{CEX(sus)}$			Vdc
(I_C = 0.1 Adc, V_{BE} = -1.5 Vdc, R_{BE} = 100 Ω)	2N6359		100	–	
	2N6360		120	–	
	2N4348		140	–	
Collector-Emitter Sustaining Voltage		$V_{CER(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0, R_{BE} = 100 Ω)	2N6359		100	–	
	2N6360		120	–	
	2N4348		140	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N6359		–	10	
(V_{CE} = 80 Vdc, I_B = 0)	2N6360		–	10	
(V_{CE} = 100 Vdc, I_B = 0)	2N4348		–	200	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N6359		–	2.0	
(V_{CE} = 110 Vdc, $V_{EB(off)}$ = 15. Vdc)	2N6360		–	2.0	
(V_{CE} = 125 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N4348		–	2.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N6359		–	10	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°)	2N6360		–	10	
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4348		–	10	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 7.0 Vdc, I_C = 0)	2N6359		–	5.0	
	2N6360				
	2N4348				
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	2N6359		15	60	
(I_C = 6.0 Adc, V_{CE} = 4.0 Vdc)	2N6360		15	60	
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)	2N4348		15	60	
(I_C = 16 Adc, V_{CE} = 4.0 Vdc)	2N6359		5.0	–	
(I_C = 12 Adc, V_{CE} = 4.0 Vdc)	2N6360		6.0	–	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N4348		10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 0.8 Adc)	2N6359		–	1.4	
(I_C = 6.0 Adc, I_B = 0.6 Adc)	2N6360		–	1.0	
(I_C = 5.0 Adc, I_B = 0.5 Adc)	2N4348		–	1.0	
(I_C = 16 Adc, I_B = 3.2 Adc)	2N6359		–	4.0	
(I_C = 12 Adc, I_B = 2.0 Adc)	2N6360		–	3.0	
(I_C = 10 Adc, I_B = 1.25 Adc)	2N4348		–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	2N6359		–	2.2	
(I_C = 6.0 Adc, V_{CE} = 4.0 Vdc)	2N6360		–	2.0	
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)	2N4348		–	2.0	
(I_C = 16 Adc, V_{CE} = 4.0 Vdc)	2N6359		–	5.0	
(I_C = 12 Adc, V_{CE} = 4.0 Vdc)	2N6360		–	4.0	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N4348		–	3.0	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 50 kHz)		f_T	200	–	kHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Max	Unit
Second Breakdown, Collector Current with base-forward biased and 1.0 s non-repetitive pulse		$I_{S/b}$			Adc
(V_{CE} = 40 Vdc)	2N6359		3.75	–	
(V_{CE} = 60 Vdc)	2N6360		2.5	–	
(V_{CE} = 80 Vdc)	2N4348		1.5	–	
Second Breakdown Energy with base-reverse biased (I_C = 2.5 Adc, V_{BE} = 4.0 Vdc, L = 40 mH, R_{BE} = 100 Ohms)		$E_{S/b}$	125	–	mJ

*Indicates JEDEC Registered Data

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE IB ≈100 mA
MSD6100 USED BELOW IB ≈100 mA

FIGURE 3 – TURN-ON TIME

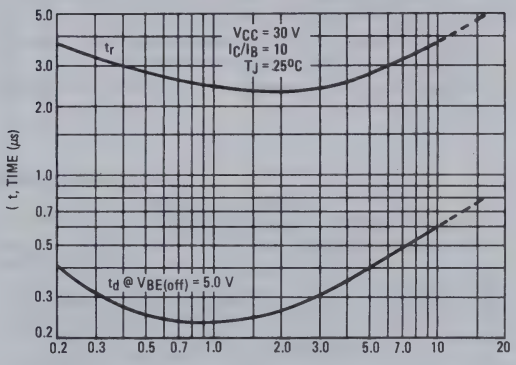


FIGURE 4 – TURN-OFF TIME

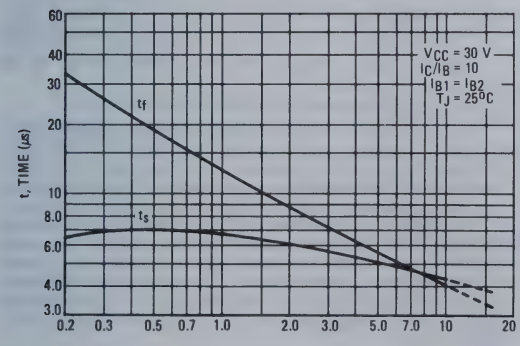


FIGURE 5 – CAPACITANCE

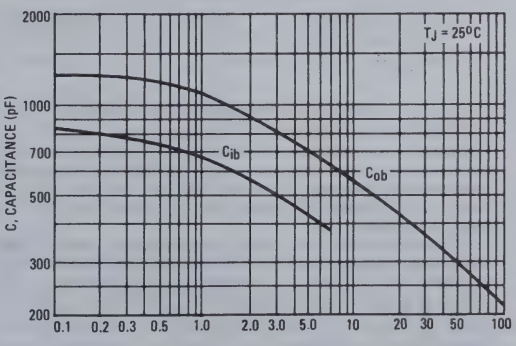


FIGURE 6 – 2N4348 THERMAL RESPONSE

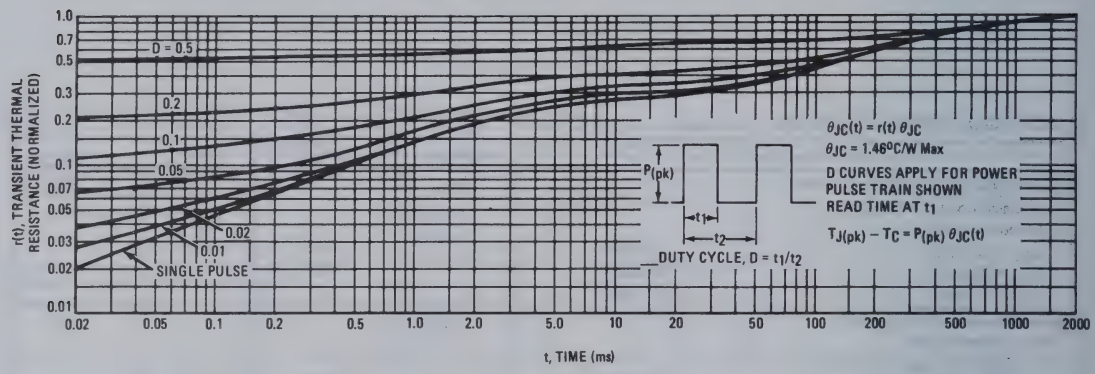
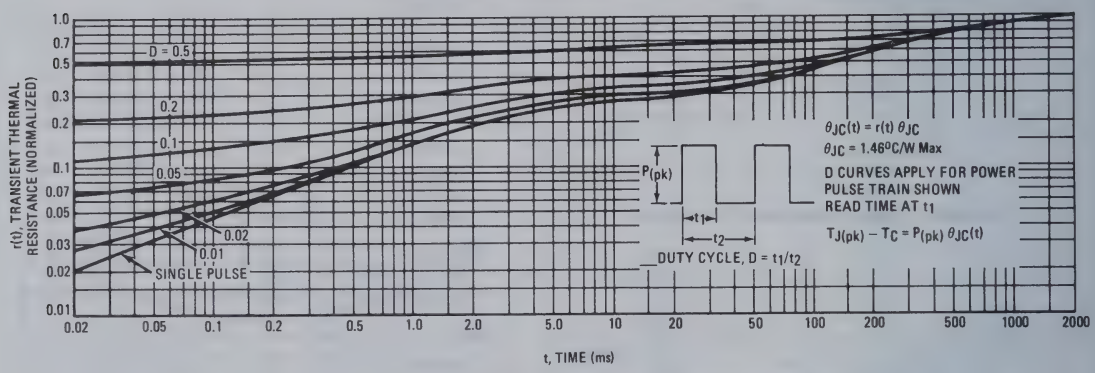


FIGURE 7 – 2N6359, 2N6360 THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 8 – 2N4348

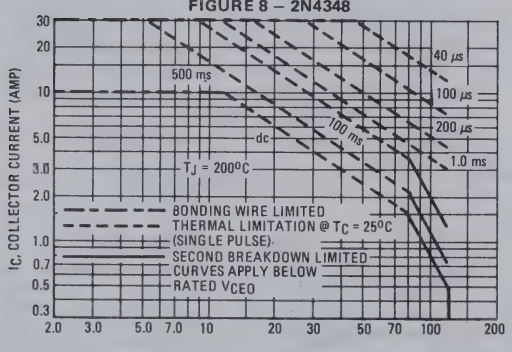
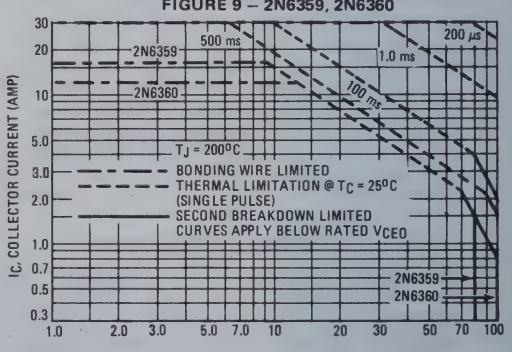


FIGURE 9 – 2N6359, 2N6360



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. (See AN-415).

Figure 8 is based upon JEDEC registered data. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated using data of Figure 6 and the pulse power limits of Figure 8. $T_{J(pk)}$ will be found to be less than $T_{J(max)}$ for pulse widths of 1.0 ms and less. When using Motorola transistors, it is permissible to increase the pulse power limits until limited by $T_{J(max)}$.

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 9 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 10 – DC CURRENT GAIN

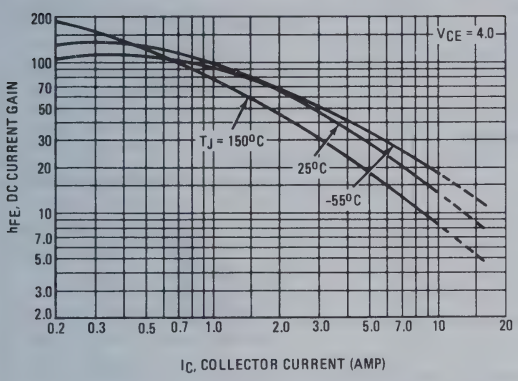


FIGURE 11 – COLLECTOR SATURATION REGION

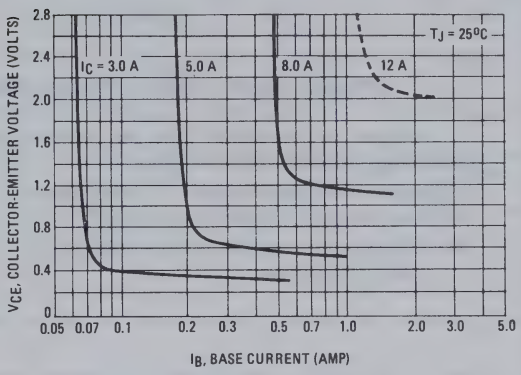


FIGURE 12 – "ON" VOLTAGE

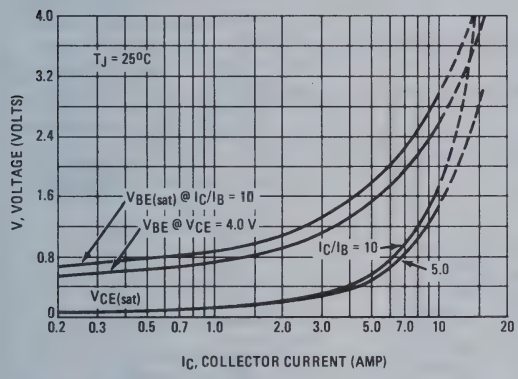


FIGURE 13 – TEMPERATURE COEFFICIENTS

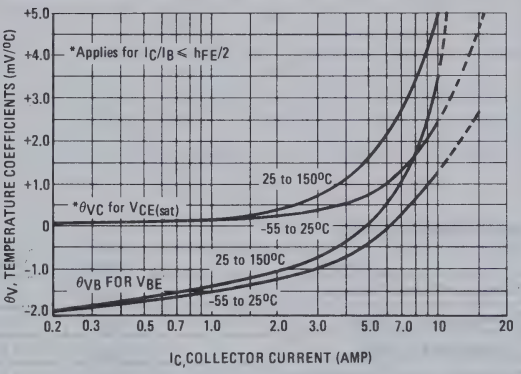
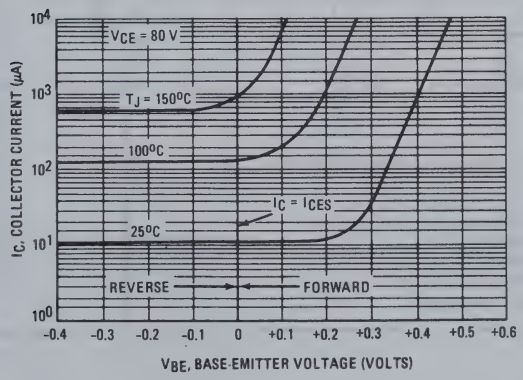


FIGURE 14 – COLLECTOR CUTOFF REGION



2N6366 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for operation in driver and predriver stages for high power linear amplifiers, 2.0 to 30 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- Power Gain @ 2.5 W (PEP) = 17 dB (Min)
- Intermodulation Distortion at Rated Power Output
  IMD = -35 dB (Max)

2.5 W (PEP)-30 MHz

RF POWER TRANSISTOR

NPN SILICON

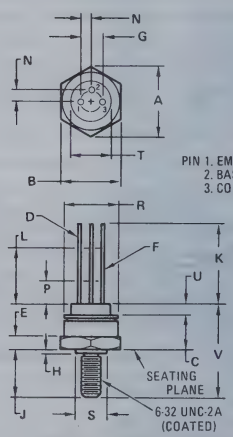


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	18	Vdc
*Collector-Base Voltage	V_{CBO}	36	Vdc
*Emitter-Base Voltage	V_{EBO}	4.0	Vdc
*Collector Current — Continuous	I_C	1.0	Adc
*Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	10 57.2	Watts mW/^oC
*Storage Temperature Range	T_{stg}	-65 to +200	^oC
Maximum Stud Torque (1)	—	2.1	in.-lb.

*Indicates JEDEC Registered Data.

(1) For repeated assembly use 1.8 in-lb maximum.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.49	11.00	0.413	0.433
B	9.19	9.53	0.362	0.375
C	5.33	5.72	0.210	0.225
D	0.406	0.533	0.016	0.021
E	1.65	1.78	0.065	0.070
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.508	0.889	0.020	0.035
J	6.73	7.42	0.265	0.292
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050
R	8.89	9.14	0.350	0.360
S	4.45	4.83	0.175	0.190
T	4.11	4.29	0.162	0.169
U	1.14	1.52	0.045	0.060

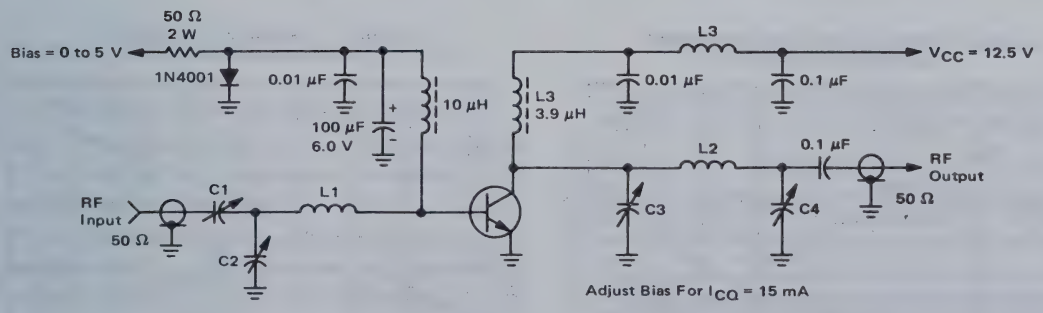
CASE 24
TO-102

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = 125°C)	I_{CES}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	50	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 150 mAdc, V_{CE} = 12.5 Vdc, f = 50 MHz)	f_T	50	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	20	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 2.5 W (PEP), f_1 = 30 MHz, f_2 = 30,001 MHz)	G_{PE}	17	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 2.5 W (PEP), f_1 = 30 MHz, f_2 = 30,001 MHz)	η	38.5	–	%
Intermodulation Distortion (V_{CC} = 12.5 Vdc, P_{out} = 2.5 W (PEP), f_1 = 30 MHz, f_2 = 30,001 MHz)	IMD	–	-35	dB

*Indicates JEDEC Registered Data

FIGURE 1 – 30 MHz TEST CIRCUIT



C1, C2 80-480 pF, ARCO 466 or equivalent
C3, C4 25-280 pF, ARCO 464 or equivalent
L1 0.1 μH Molded Choke
L2 0.15 μH Molded Choke
L3 Ferrite Choke, FERROXCUBE VK200 01-03B or equivalent

FIGURE 2 – LINEAR OUTPUT POWER versus FREQUENCY

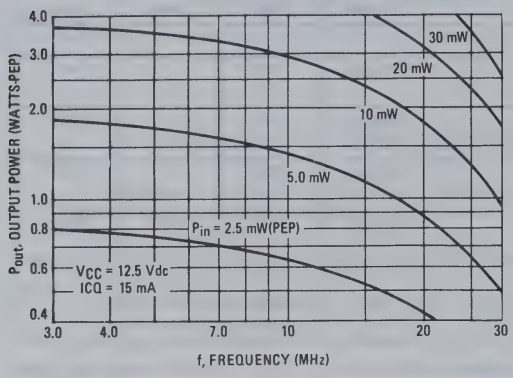


FIGURE 3 – OUTPUT POWER versus INPUT POWER (30 MHz)

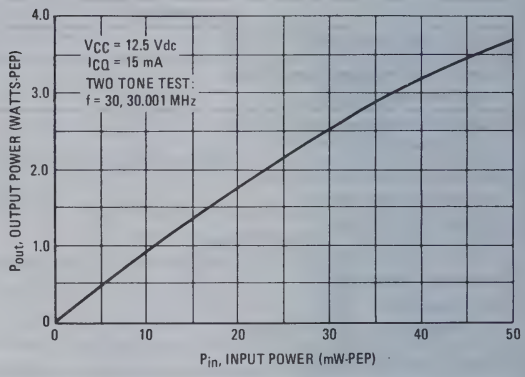


FIGURE 4 – OUTPUT POWER versus INPUT POWER (12 MHz)

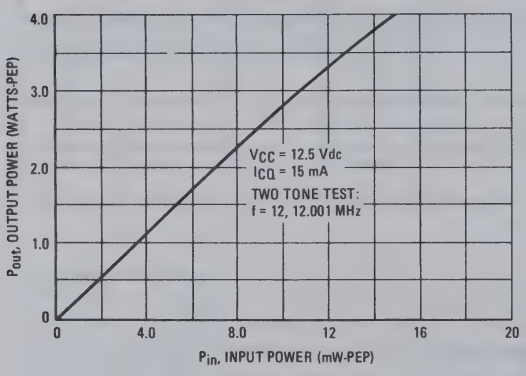


FIGURE 5 – OUTPUT POWER versus INPUT POWER (3.0 MHz)

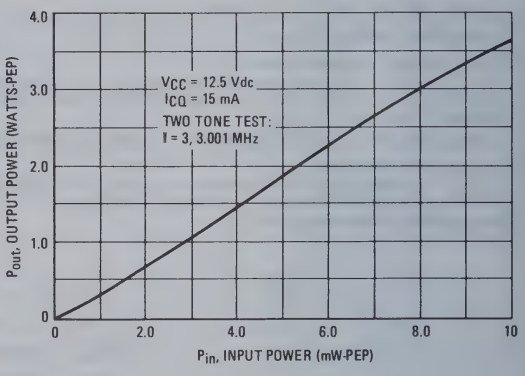


FIGURE 6 – INTERMODULATION DISTORTION versus OUTPUT POWER

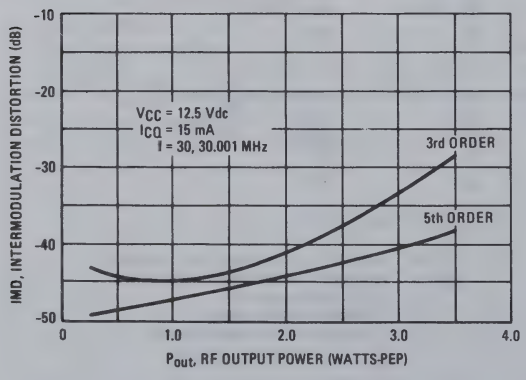


FIGURE 7 – LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

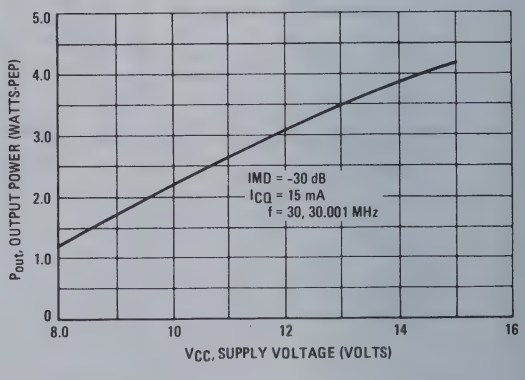


FIGURE 8 – PARALLEL EQUIVALENT INPUT RESISTANCE

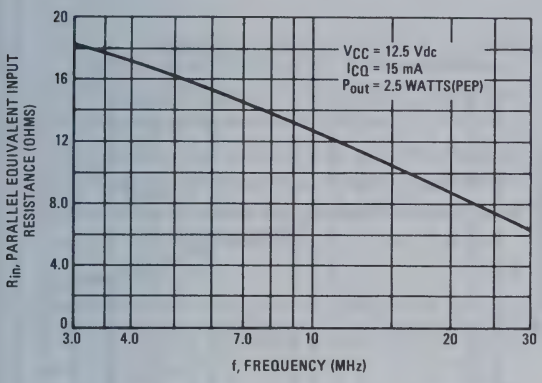


FIGURE 9 – PARALLEL EQUIVALENT INPUT CAPACITANCE

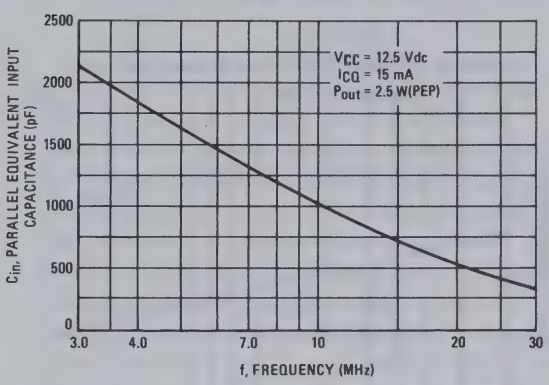


FIGURE 10 – PARALLEL EQUIVALENT OUTPUT RESISTANCE

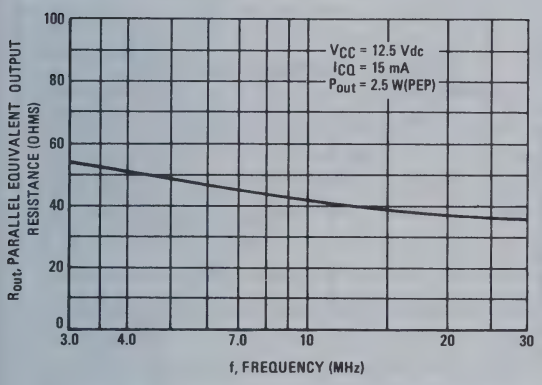


FIGURE 11 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE

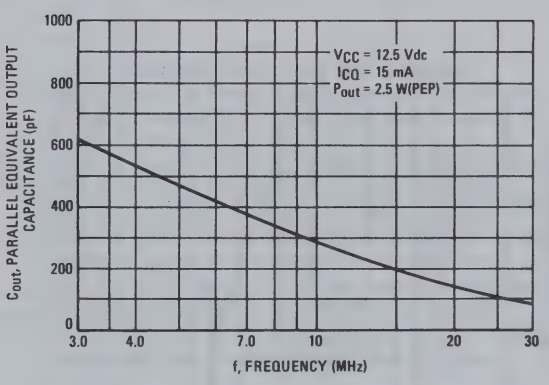


FIGURE 12 – CURRENT-GAIN – BANDWIDTH PRODUCT

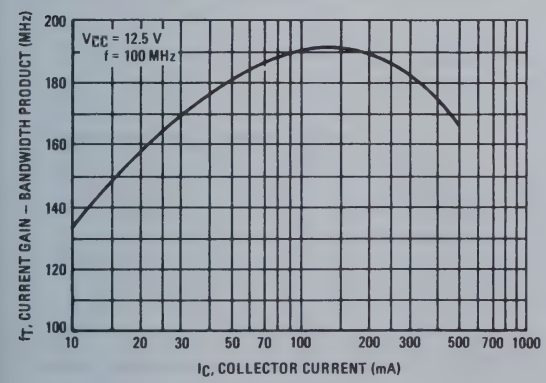


FIGURE 13 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

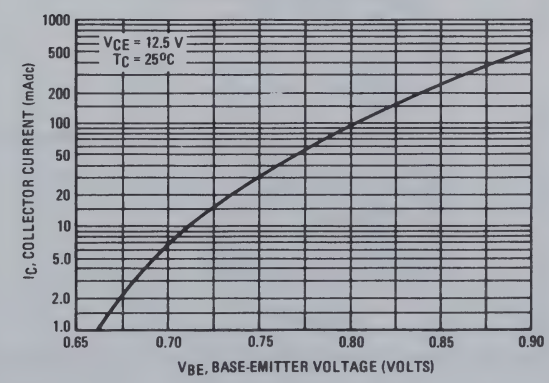


FIGURE 14 – OUTPUT CAPACITANCE versus VOLTAGE

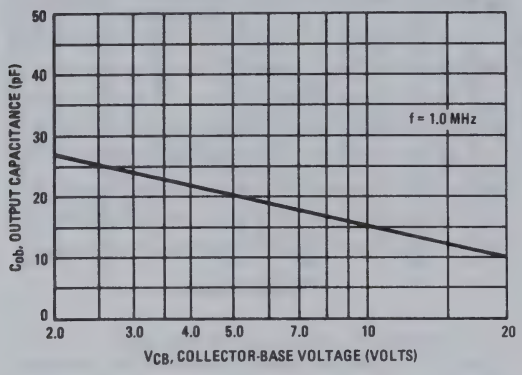


FIGURE 15 – INPUT CAPACITANCE versus VOLTAGE

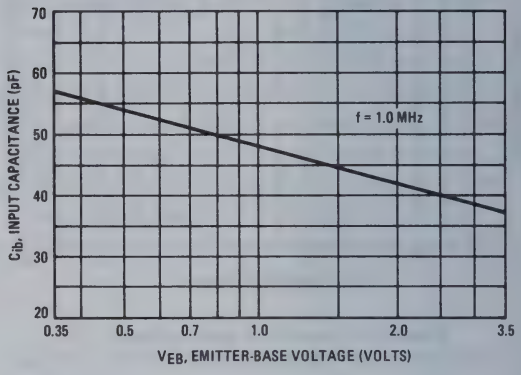


FIGURE 16 – DC SAFE OPERATING AREA

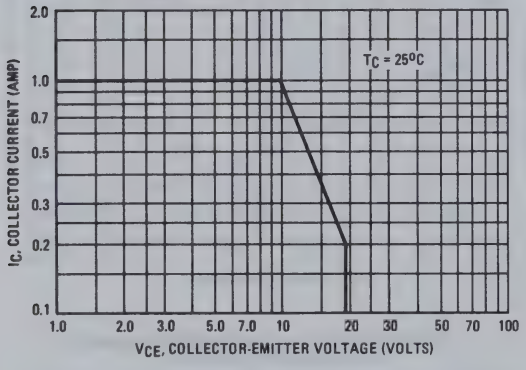
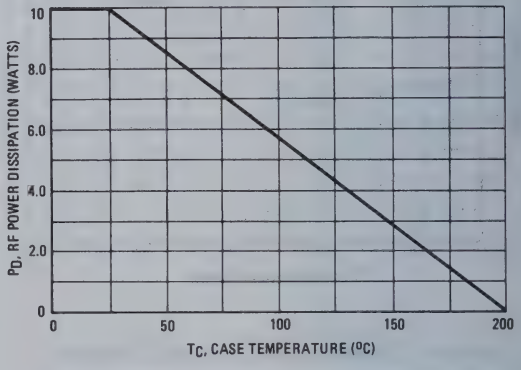


FIGURE 17 – RF POWER DISSIPATION



2N6367 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

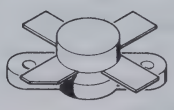
. . . designed primarily for driver applications in 12.5 volt single-sideband amplifiers from 2.0 to 30 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- Power Output @ 12.5 Vdc, 30 MHz — 9.0 W (PEP)
- Intermodulation Distortion at Rated Power Output — IMD = -30 dB (Max)

9 W (PEP) — 30 MHz

RF POWER TRANSISTOR

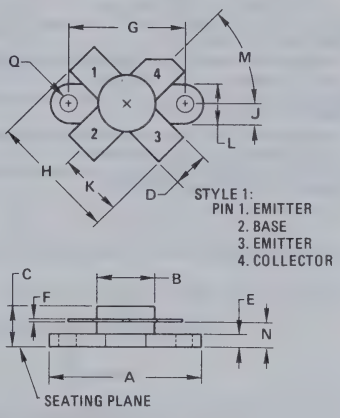
NPN SILICON



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20 0.114	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

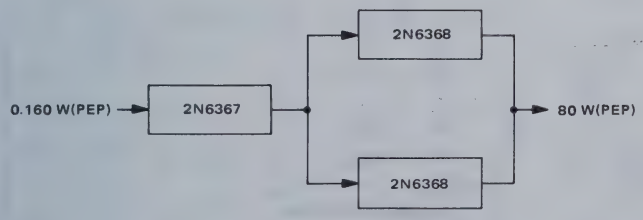
*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	9.47	9.73	0.373	0.383
C	6.07	7.14	0.239	0.281
D	5.59	5.84	0.220	0.230
E	2.16	2.67	0.085	0.105
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	21.59	22.10	0.850	0.870
J	3.12	3.23	0.123	0.127
K	10.80	11.05	0.425	0.435
L	6.22	6.48	0.245	0.255
M	40^o	50^o	40^o	50^o
N	3.81	4.57	0.150	0.180
Q	2.97	3.12	0.117	0.123

CASE 211-01

TYPICAL DRIVER APPLICATION
2-30 MHz WIDE BAND AMPLIFIER

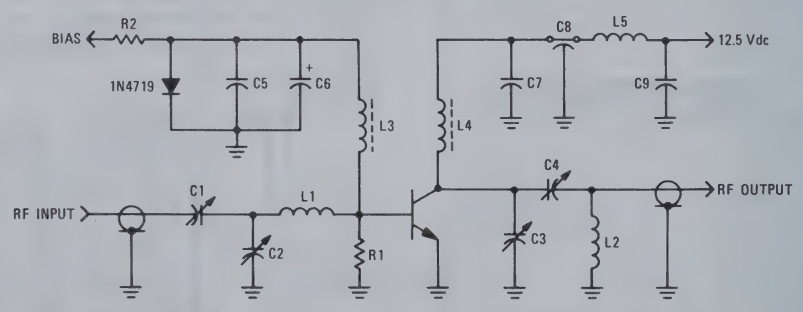


***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	50	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 500 mAdc, V_{CE} = 12.5 Vdc, f = 50 MHz)	f_T	50	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	90	pF
FUNCTIONAL TESTS				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 9.0 W(PEP), $I_{C(max)}$ = 1.0 Adc, f_1 = 30 MHz, f_2 = 30.001 MHz)	G_{PE}	14	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 9.0 W(PEP), $I_{C(max)}$ = 1.0 Adc, f_1 = 30 MHz, f_2 = 30.001 MHz)	η	36	–	%
Intermodulation Distortion (V_{CC} = 12.5 Vdc, P_{out} = 9.0 W(PEP), $I_{C(max)}$ = 1.0 Adc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IMD	–	-30	dB

*Indicates JEDEC Registered Data

FIGURE 1 – 30 MHz TEST CIRCUIT



C1, C3	25-280 pF, ARCO 464 OR EQUIVALENT	L2	5 TURNS #18 AWG, 1/4" ID, 5/16" LONG (0.13 μH)
C2, C4	170-780 pF, ARCO 469 OR EQUIVALENT	L3	3.3 μH
C5, C7, C9	0.1 μF	L4	1.0 μH
C6	500 μF TANTALUM	L5	FERROXCUBE VK 200 20/4B
C8	680 pF FEED THRU	R1	10 OHMS
L1	3 TURNS #18 AWG, 1/4" ID, 1/4" LONG (60 nH)	R2	50 OHMS

ADJUST BIAS FOR I_{CQ} = 35 mA WITH NO RF SIGNAL APPLIED

FIGURE 2 – LINEAR OUTPUT POWER versus FREQUENCY

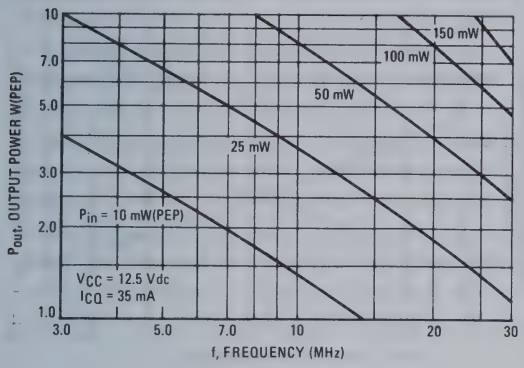


FIGURE 3 – OUTPUT POWER versus INPUT POWER

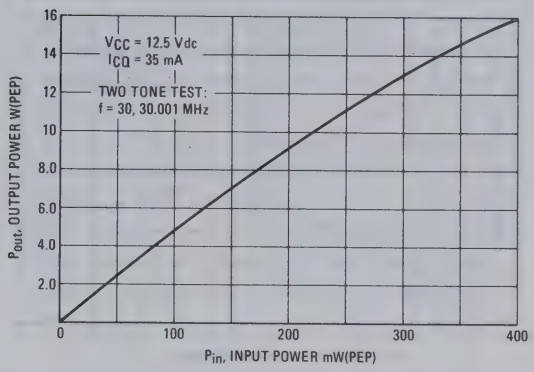


FIGURE 4 – OUTPUT POWER versus INPUT POWER

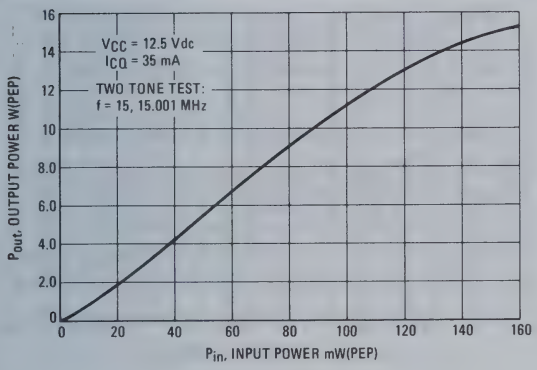


FIGURE 5 – OUTPUT POWER versus INPUT POWER

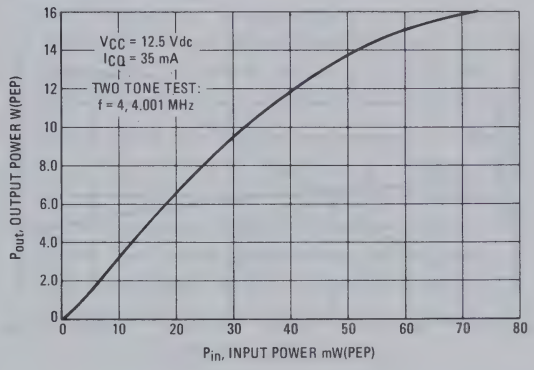


FIGURE 6 – INTERMODULATION DISTORTION versus OUTPUT POWER

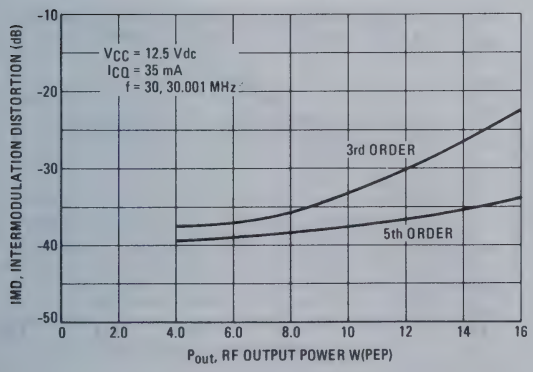


FIGURE 7 – LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

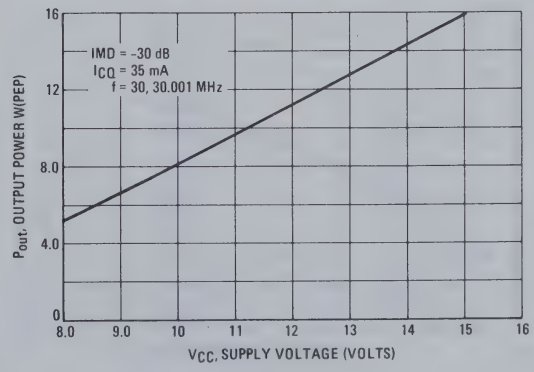


FIGURE 8 – PARALLEL EQUIVALENT INPUT RESISTANCE

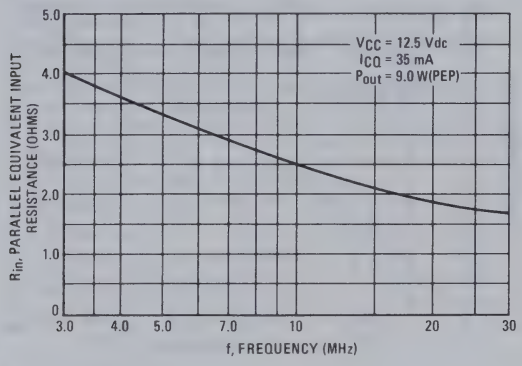


FIGURE 9 – PARALLEL EQUIVALENT INPUT CAPACITANCE

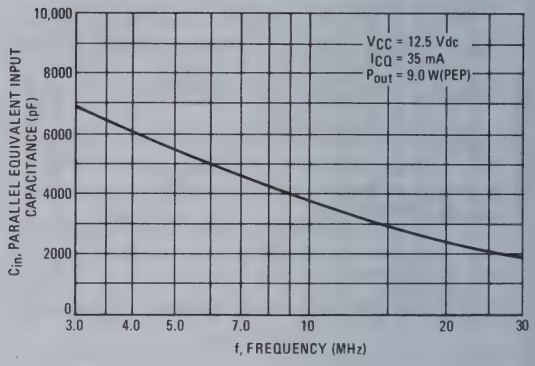


FIGURE 10 – PARALLEL EQUIVALENT OUTPUT RESISTANCE

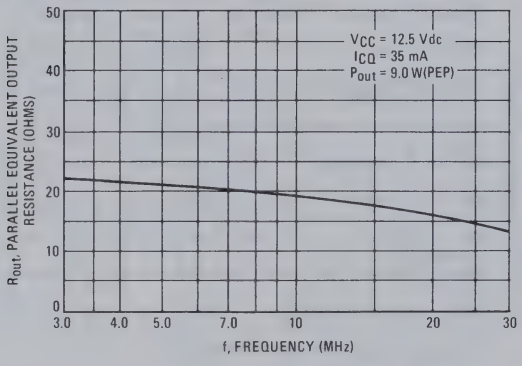


FIGURE 11 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE

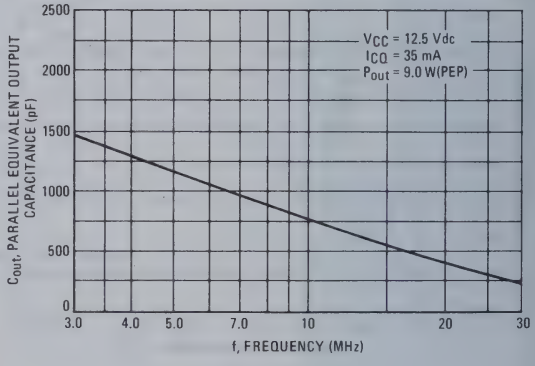


FIGURE 12 – CURRENT-GAIN – BANDWIDTH PRODUCT

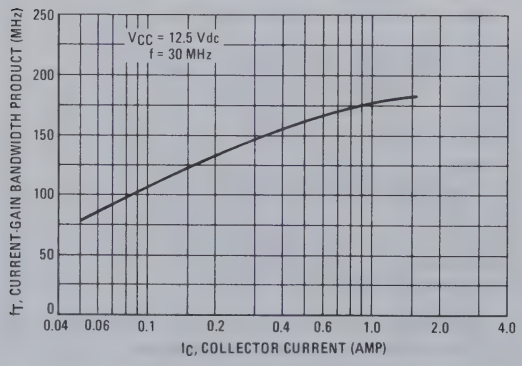


FIGURE 13 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

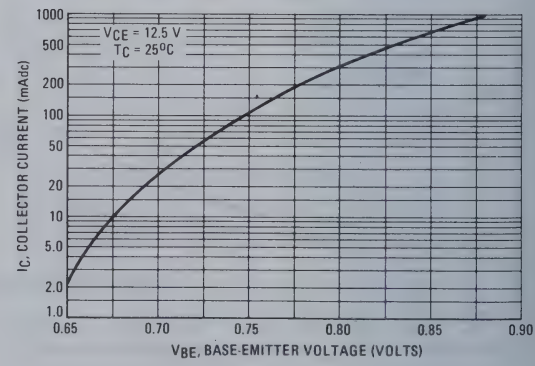


FIGURE 14 – OUTPUT CAPACITANCE

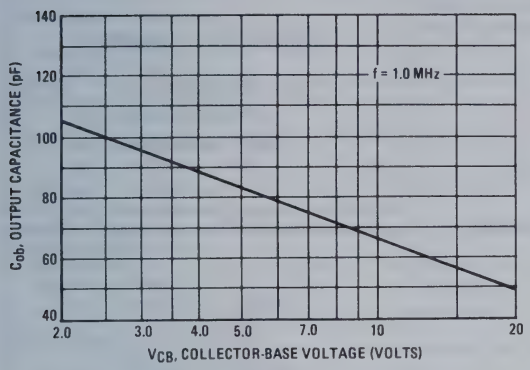


FIGURE 15 – INPUT CAPACITANCE

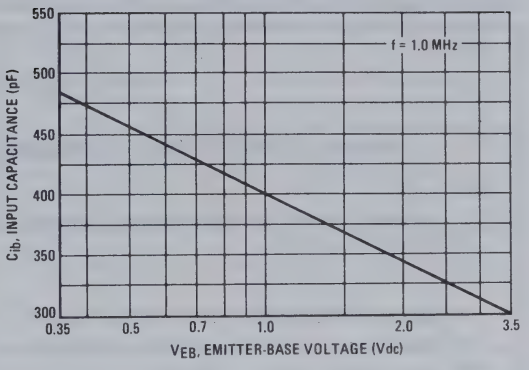


FIGURE 16 – DC SAFE OPERATING AREA

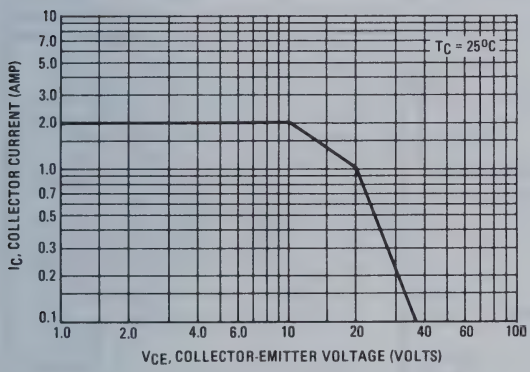
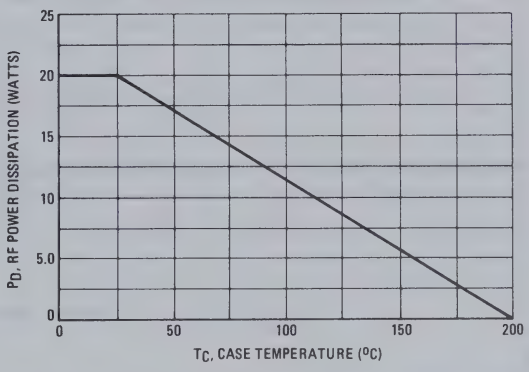


FIGURE 17 – RF POWER DISSIPATION



2N6368 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

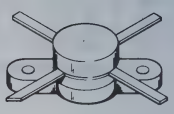
. . . designed primarily for applications as a high-power linear amplifier from 2.0 to 30 MHz.

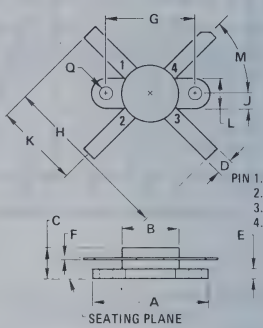
- Optimized for Operation from a 12.5 Volt Supply
- Power Output @ 12.5 Vdc, 30 MHz = 40 W (PEP)
- Power Gain @ 30 MHz = 10 dB (Min)
- Intermodulation Distortion at Rated Power Output — IMD = -30 dB (Max)
- Isothermal-Resistor Design Results in Rugged Device

40 W (PEP) — 30 MHz

RF POWER TRANSISTOR

NPN SILICON





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	11.81	12.07	0.465	0.475
C	5.82	6.73	0.229	0.265
D	2.16	3.94	0.085	0.155
E	2.13	2.54	0.084	0.100
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	35.56	38.10	1.400	1.500
J	3.12	3.23	0.123	0.127
K	17.78	19.05	0.700	0.750
L	6.22	6.48	0.245	0.255
M	40°	50°	40°	50°
N	3.66	4.32	0.144	0.170
Q	2.97	3.12	0.117	0.123

CASE 211-02

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	8.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	140 0.8	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

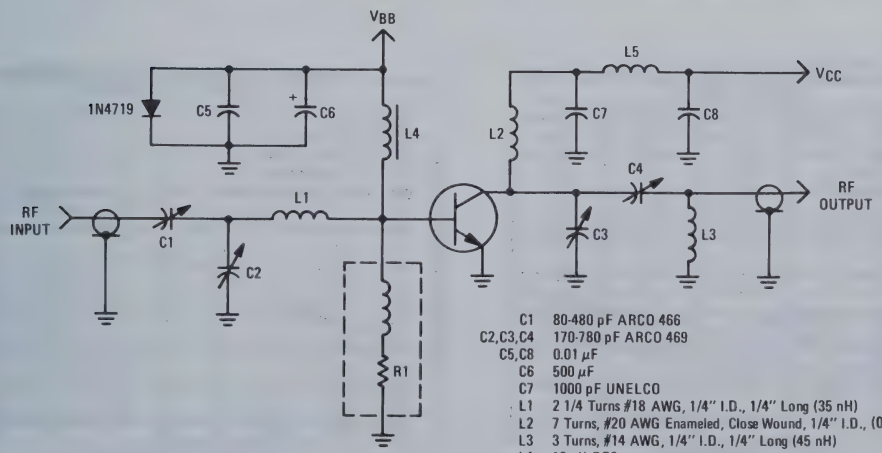
*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 12.5 Vdc, V_{BE} = 0, T_C = +55°C)	I_{CES}	–	–	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	20	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12.5 Vdc, f = 50 MHz)	f_T	50	110	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	300	350	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 40 W (PEP), I_C = 4.7 Adc Max, V_{CC} = 12.5 Vdc, I_{CQ} = 50 mAdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	G_{PE}	10	11.2	–	dB
Intermodulation Distortion Ratio (Figure 1) (P_{out} = 40 W (PEP), I_C = 4.7 Adc Max, V_{CC} = 12.5 Vdc, I_{CQ} = 50 mAdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IMD	–	-35	-30	dB
Collector Efficiency (Figure 1) (P_{out} = 40 W (PEP), I_C = 4.7 Adc Max, V_{CC} = 12.5 Vdc, I_{CQ} = 50 mAdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	η	34	40	–	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 30 MHz TEST CIRCUIT



C1 80-480 pF ARCO 466
C2,C3,C4 170-780 pF ARCO 469
C5,C8 0.01 μF
C6 500 μF
C7 1000 pF UNELCO
L1 2 1/4 Turns #18 AWG, 1/4" I.D., 1/4" Long (35 nH)
L2 7 Turns, #20 AWG Enameled, Close Wound, 1/4" I.D., (0.2 μH)
L3 3 Turns, #14 AWG, 1/4" I.D., 1/4" Long (45 nH)
L4 10 μH RFC
L5 RF Choke Ferroxcube VK200-20-4B
R1 10 Ohms, Wirewound, 1 W (0.25 μH Inductance)

FIGURE 2 – LINEAR OUTPUT POWER versus FREQUENCY

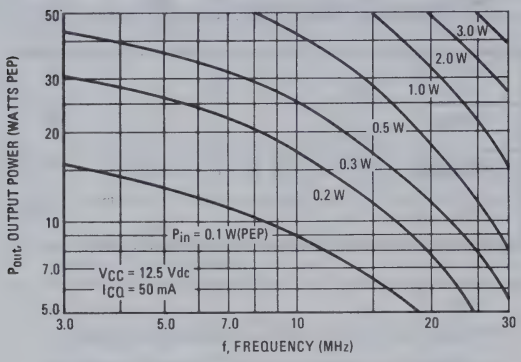


FIGURE 3 – OUTPUT POWER versus INPUT POWER

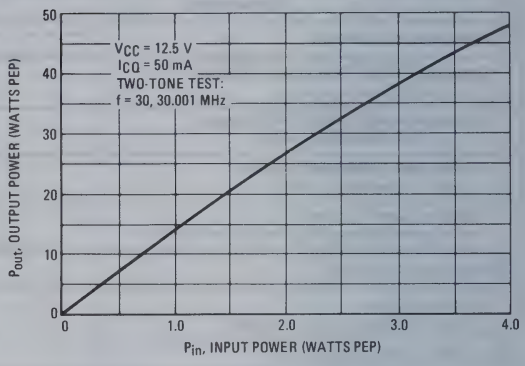


FIGURE 4 – OUTPUT POWER versus INPUT POWER

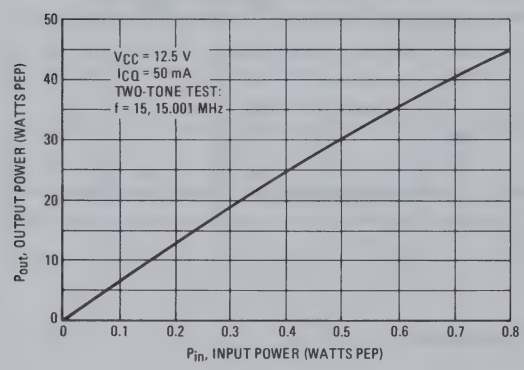


FIGURE 5 – OUTPUT POWER versus INPUT POWER

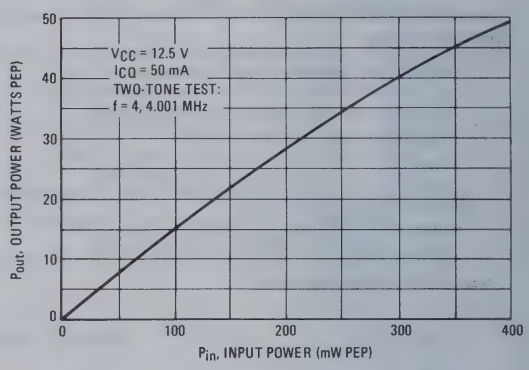


FIGURE 6 – INTERMODULATION DISTORTION versus OUTPUT POWER

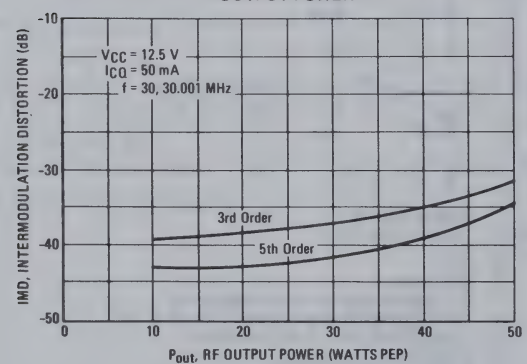


FIGURE 7 – LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

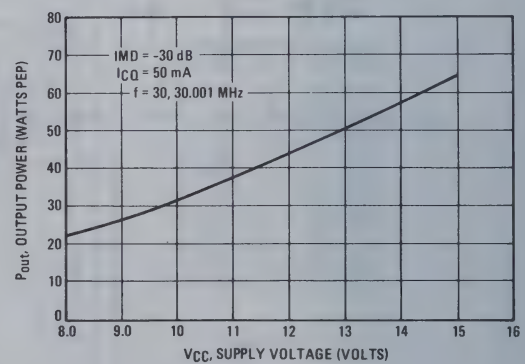


FIGURE 8 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

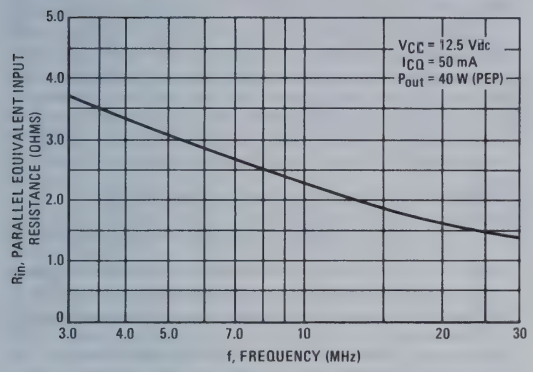


FIGURE 9 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

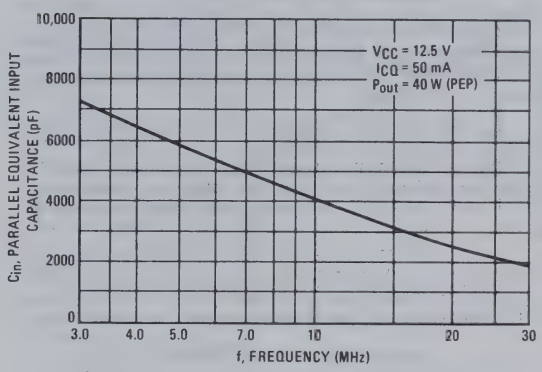


FIGURE 10 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

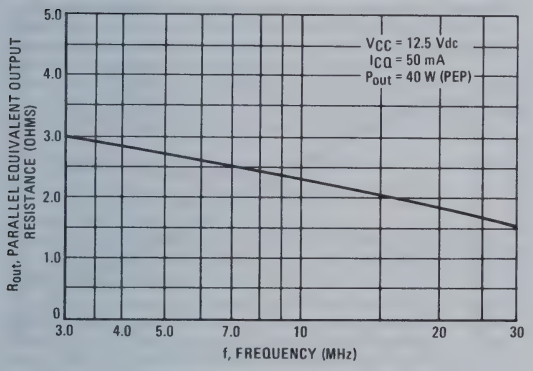


FIGURE 11 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

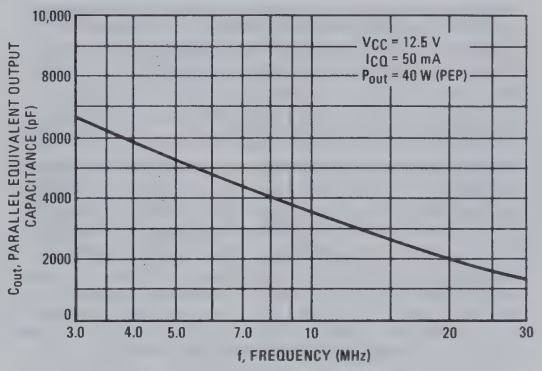


FIGURE 12 – CURRENT-GAIN – BANDWIDTH PRODUCT

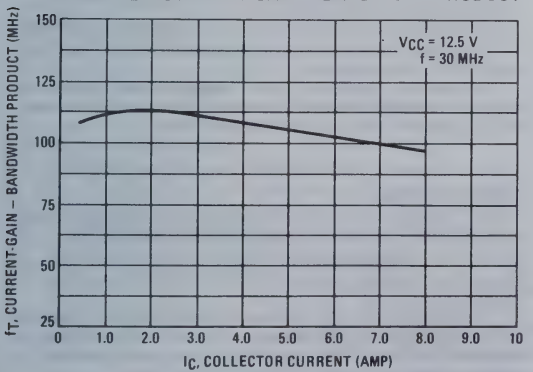


FIGURE 13 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

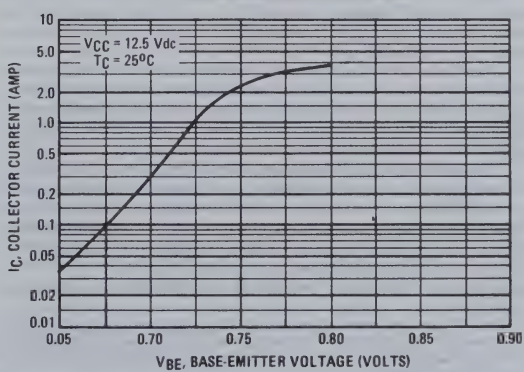


FIGURE 14 – OUTPUT CAPACITANCE versus VOLTAGE

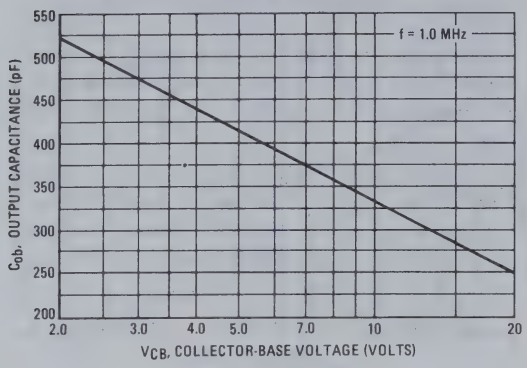


FIGURE 15 – INPUT CAPACITANCE versus VOLTAGE

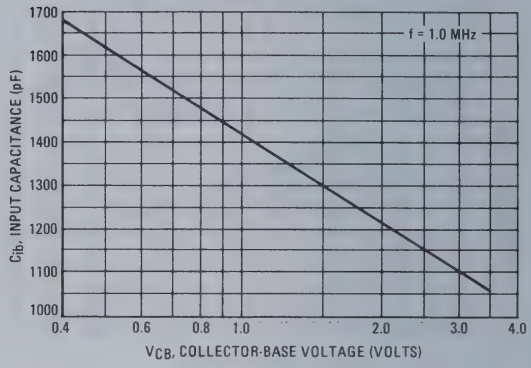


FIGURE 16 – DC SAFE OPERATING AREA

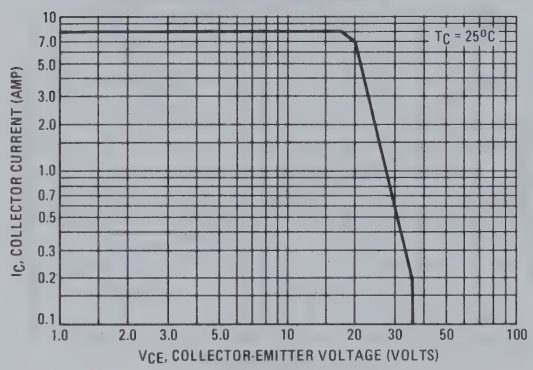
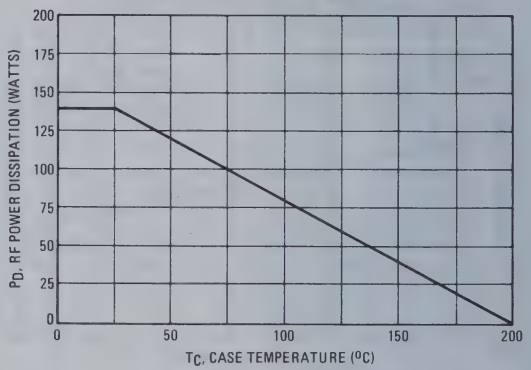


FIGURE 17 – RF POWER DISSIPATION



APPLICATIONS INFORMATION

The 2N6368 transistor is designed for linear power amplifier operation in the HF region (2 to 30 MHz). It features guaranteed linear amplifier performance rather than the conventional performance demonstrated in a class C* amplifier.

Class C operation is inherently non-linear, but in many power amplifier applications non-linear operation does not present major problems. With a single frequency driving signal, the only spurious signals generated are harmonics and these can be supressed in the amplifier tuned networks and output filter.

For single sideband (SSB), low level amplitude modulation (AM), and other types of complex signals, class C operation is generally not satisfactory. For instance, when a signal contains multiple frequencies at close spacings, odd-order non-linearities will generate spurious outputs which are within the passband of the tuned circuits and filters; therefore, the spurious outputs are not suppressed before they reach the antenna or other load. As a result, such complex signals require linear amplification if the amplified signal is to be free of spurious outputs.

A detailed analysis of spurious signals generated by non-linearities and linearity requirements of various applications is described in Chapter 12 of Reference 1.

The following discussion concerns itself with a detailed description of the 2N6368 characterization curves and general information on solid-state linear power amplifier design.

The Two-Tone Test

The 2N6368 functional test specifications consists of a linear power amplifier test with guaranteed limits on power output, gain, efficiency, and intermodulation distortion (IMD) output levels. A two-tone test signal is used with the test amplifier as shown in Figure 1.

The two-tone test is one of many methods commonly used for testing linear amplifier performance. This test involves driving the amplifier with two RF signals, of equal amplitude, separated in frequency from each other by approximately 1 kHz.

*"Class C", as used here refers to operation with the no signal conditions I_C = 0, and V_{BE} = 0, and a theoretical conduction angle of less than 180°, even though the actual conduction angle may be more than 180°.

APPLICATIONS INFORMATION (continued)

When a two-tone test signal consisting of frequencies f_1 and f_2 is passed through a non-linear amplifier, odd order non-linearities generate spurious signals near the desired carrier. The level of these spurious signals provides a measure of the degree of non-linearity of the amplifier. This type of non-linearity is called intermodulation distortion (IMD). The spurious signals generated by IMD are further classified according to the exponential order of the amplifier non-linearity, i.e., 3rd order IMD products, 5th order IMD products, etc. The 3rd and 5th order IMD products are usually the most significant encountered with linear power amplifiers. Data on both 3rd and 5th order IMD are included in the 2N6368 characterization.

Third order IMD generates spurious signals near the operating frequency at frequencies $2f_1 - f_2$ and $2f_2 - f_1$; and 5th order IMD spurious are at frequencies $3f_1 - 2f_2$ and $3f_2 - 2f_1$.

Specifications and Characterization

The two-tone functional amplifier test is performed in a manner identical to the conventional class C functional test with two exceptions: a two-frequency signal is used in place of a single frequency, and amplifier linearity is added to the items tested and specified.

The functional test procedure for the 2N6368 require driving the test amplifier with a two-frequency signal and measuring power output, gain, efficiency, and linearity.

Power output, gain and efficiency measurement methods are the same for both linear and class C amplifier.

Since a multiple frequency test signal has an instantaneous power level which varies with time, power levels are normally expressed in peak envelope power (PEP). This is the average power level of the envelope at its greatest amplitude point.

When the test signal consists of multiple signals with equal amplitudes and different frequencies, the relationship of average power and PEP is given by the following expression:

$$\text{Average power} = \frac{\text{PEP}}{N}$$

where N = the number of input frequencies.

Therefore, when measuring the power level of a standard two-tone test signal, a true average reading power meter will indicate 1/2 the PEP of the signal.

Linearity is tested by measuring the amplitudes of the 3rd and 5th order IMD products. The ratio of one of the 3rd order products to one of the two desired frequencies is then expressed as a power ratio in decibels (dB). This is repeated for the 5th order products. The smaller of these two ratios (usually the 3rd order) is then included in the electrical characteristics specifications as intermodulation distortion ratio (IMD).

2N6368 Performance Curves

Figures 2 through 5 show typical power output and gain characteristics versus frequency and/or input power. These curves are similar to those found on other RF power transistor data sheets with one exception, a two-frequency test signal was used rather than a single frequency signal.

The curves shown in Figure 6 are unique to transistors characterized for linear power amplifier service and show the typical IMD levels versus power output.

The 2N6368 features guaranteed IMD performance at the -30 dB level. However, the designer may desire IMD greater or less than -30 dB for a particular application. Figure 6 provides data on IMD levels that can be expected as a function of output power.

Figure 7 reflects the power output that can be obtained at a fixed IMD ratio for operation with dc supply voltages other than 12.5 Vdc.

Figures 8 through 11 show the large signal impedance characteristics of the 2N6368. These are similar to curves shown on other Motorola data sheets except a two-frequency test signal was used rather than a single frequency signal.

It must be stressed that the data shown in Figures 8 through 11 do not represent y, z, h, s, or any standard two-port parameter set. The actual transistor impedance levels during normal operation in a power amplifier are given. For a detailed discussion of RF power transistor large signal impedance, see Reference 2.

Linear Amplifier Design

The following is a discussion of some general design considerations for solid-state linear power amplifiers. While this is not a detailed analysis of linear amplifier design, some general guidelines are provided.

The major difference between linear power amplifiers and class C power amplifiers is in the dc bias circuitry. As stated in the introduction, class C operation usually involves a collector dc supply as the only bias voltage with $V_E = V_B = 0$. The collector current is zero until the input RF signal turns the transistor "on."

In contrast, a linear amplifier is normally operated with forward bias and some collector current flowing when no signal is present.

The magnitude of no-signal collector current and the bias circuitry may vary with the application. Optimum no-signal collector current for the 2N6368 was found to be approximately 50 mA.

The key to bias circuitry for good linearity lies in maintaining the base-emitter dc voltage relatively constant as the RF signal amplitude varies. The inherent nature of a forward-biased RF power transistor is to bias itself "off" with increasing RF drive signal. Therefore, a constant voltage source is required for base voltage.

Temperature effects also complicate the situation, since V_{BE} decreases with increasing temperature.

A simple solution to the bias problem involves the use of a forward-biased diode mounted on the transistor heat sink for thermal coupling to the transistor. A sample of this technique is shown in the test circuit of Figure 1. The reader is referred to reference 3 for a detailed description of the operation of this bias circuit. It is also possible to use complex active circuitry for biasing, and some rather exotic schemes have been developed to provide the same results.

Another important consideration is the collector-output network. Normally, a network with low impedance to ground for harmonics provides better linearity than a network with high harmonic impedances; therefore, some experimentation with network configuration is in order. Proper impedance matching remains the primary factor in both input and output network design. Further, it must also be stressed that the collector load impedance should be designed for the PEP, not the average power output. See Chapter 13 of Reference 1 for a detailed discussion of network design considerations.

Feedback may also be employed to improve linearity and may take the form of either neutralization or negative RF feedback. The possibilities here are limited only by the designer's imagination. Of course, negative RF feedback involves a decrease in gain to improve linearity.

REFERENCES

1. Pappenfus, Bruene, Schoenike, "Single Sideband Principles and Circuits", McGraw-Hill.
2. Hejhall, "Systemizing RF Power Amplifier Design", Motorola Semiconductor Products Inc., Application Note AN-282A.
3. Hejhall, "Solid-State Linear Power Amplifier Design," Motorola Semiconductor Products Inc., Application Note AN-546.

2N6370 (SILICON)

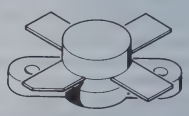
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed primarily as a driver for high-power linear amplifier stages operating from 2.0 to 30 MHz with a 28-Volt supply.

- Power Output @ 28 Vdc, 30 MHz – 10 W (PEP)
- Intermodulation Distortion at Rated Power Output – IMD = -30 dB (Max)

10 W (PEP) – 30 MHz RF POWER TRANSISTOR NPN SILICON

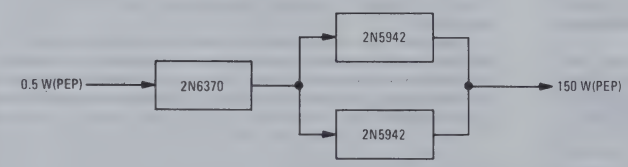


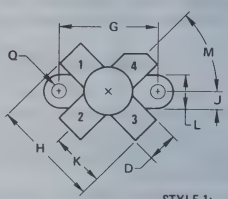
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	65	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	1.5	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20 0.114	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

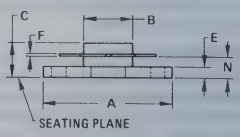
*Indicates JEDEC Registered Data

TYPICAL DRIVER APPLICATION





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.64	24.89	0.970	0.980
B	9.47	9.73	0.373	0.383
C	6.07	7.14	0.239	0.281
D	5.59	5.84	0.220	0.230
E	2.16	2.67	0.085	0.105
F	0.10	0.15	0.004	0.006
G	18.29	18.54	0.720	0.730
H	21.59	22.10	0.850	0.870
J	3.12	3.23	0.123	0.127
K	10.80	11.05	0.425	0.435
L	6.22	6.48	0.245	0.255
M	40^o	50^o	40^o	50^o
N	3.81	4.57	0.150	0.180
Q	2.97	3.12	0.117	0.123

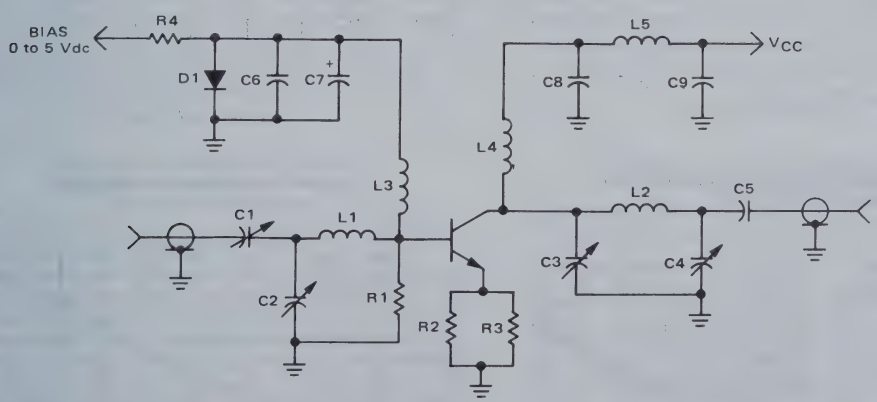
CASE 211-01

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	65	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, V_{BE} = 0, T_C = +55°C)	I_{CES}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	50	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 15 Vdc, f = 50 MHz)	f_T	50	–	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 10 W(PEP), I_C = 470 mAdc Max, V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	G_{PE}	12	–	dB
Intermodulation Distortion Ratio (Figure 1) (P_{out} = 10 W(PEP), I_C = 470 mAdc Max, V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IMD	–	-30	dB
Collector Efficiency (P_{out} = 10 W(PEP), I_C = 470 mAdc Max, V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	η	38	–	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 30 MHz TEST CIRCUIT



C1	80 – 480 pF	ARCO 466 or equivalent	L2	5 Turns, #18 AWG, 1/4" I.D., 5/16" Long (0.13 μH)	
C2,C3,C4	170 – 780 pF	ARCO 469 or equivalent	L3	10 μH	
C5	0.1 μF		L4	1.0 μH	
C6,C9	0.01 μF		L5	RFC VK200 FERROXCUBE	
C7	500 μF	TANTALUM or equivalent	R1	10 OHMS 1/2 W ALLEN BRADLEY or equivalent	
C8	2000 pF	UNELCO or equivalent	R2,R3	1.5 OHMS 1/2 W ALLEN BRADLEY or equivalent	
D1	1N4001		R4	50 OHMS 1/2 W ALLEN BRADLEY or equivalent	
L1	4 Turns, #18 AWG, 1/2" I.D., 1/4" Long (0.1 μH)		ADJUST BIAS FOR I_{CQ} = 10 mA		

FIGURE 2 – LINEAR OUTPUT POWER versus FREQUENCY

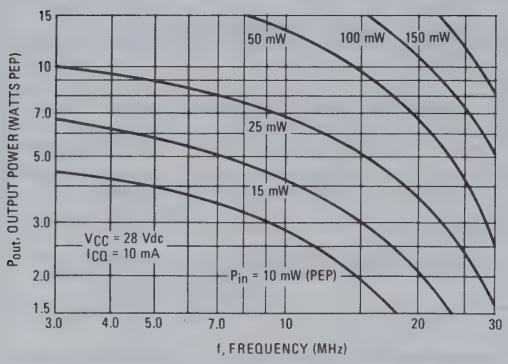


FIGURE 3 – OUTPUT POWER versus INPUT POWER

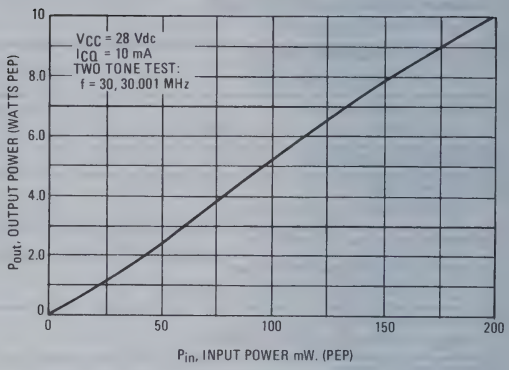


FIGURE 4 – OUTPUT POWER versus INPUT POWER

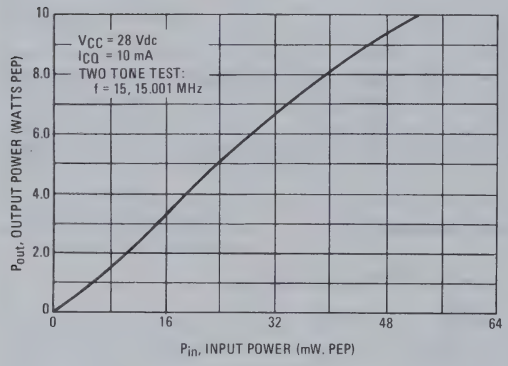


FIGURE 5 – OUTPUT POWER versus INPUT POWER

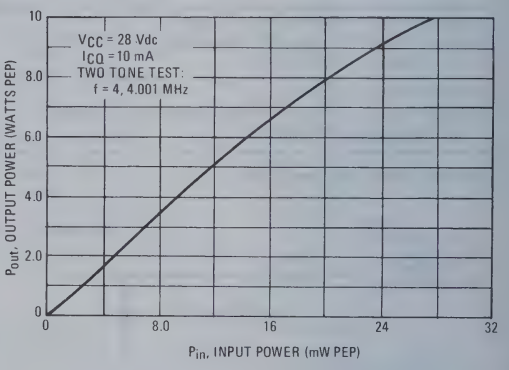


FIGURE 6 – INTERMODULATION DISTORTION versus OUTPUT POWER

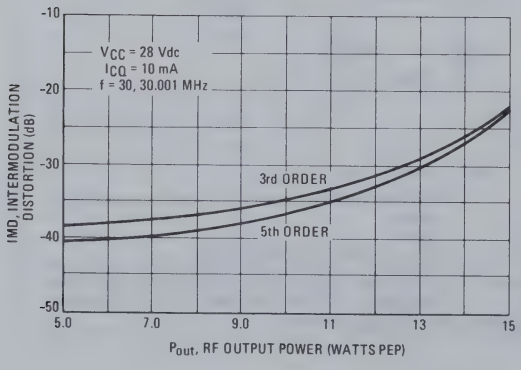


FIGURE 7 – LINEAR OUTPUT POWER versus SUPPLY VOLTAGE

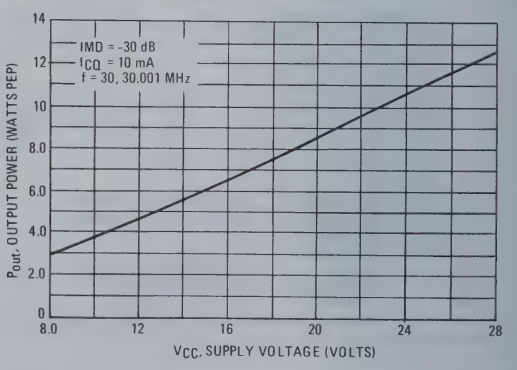


FIGURE 8 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

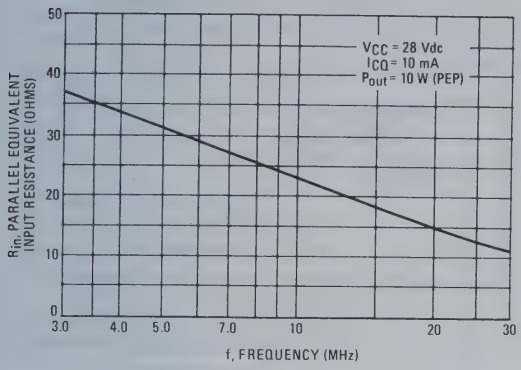


FIGURE 9 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

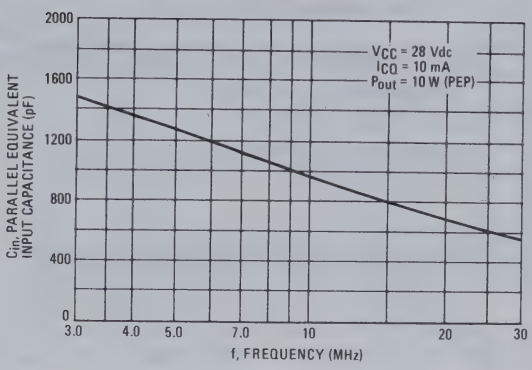


FIGURE 10 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

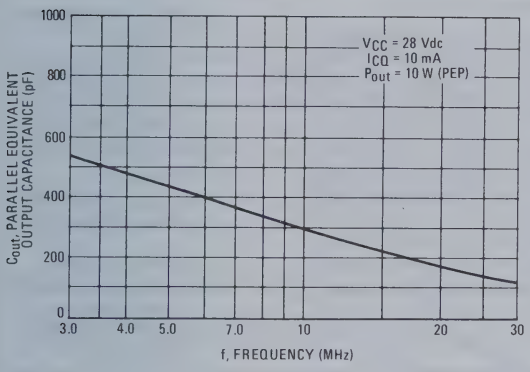


FIGURE 11 – CURRENT GAIN – BANDWIDTH PRODUCT

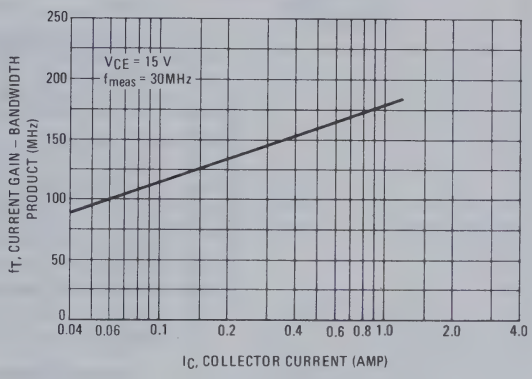


FIGURE 12 – INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE

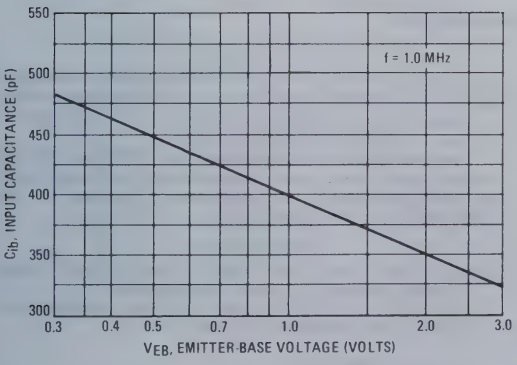


FIGURE 13 – OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE

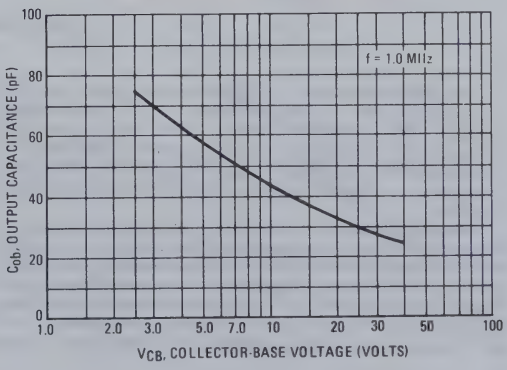


FIGURE 14 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

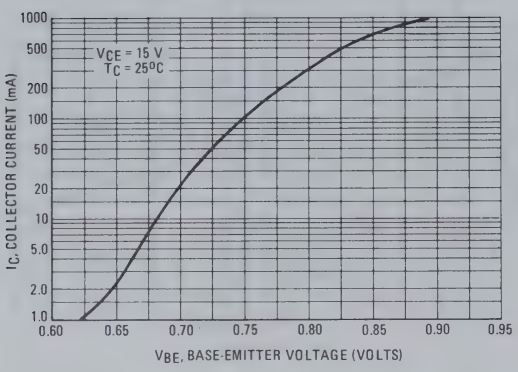


FIGURE 15 – RF POWER DERATING

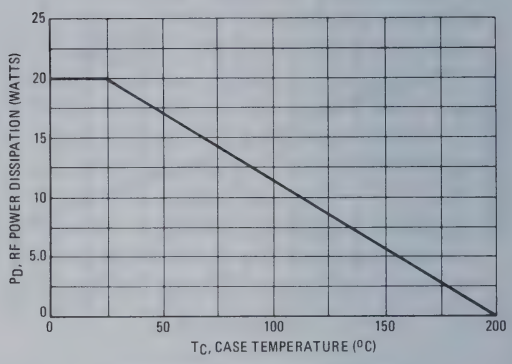
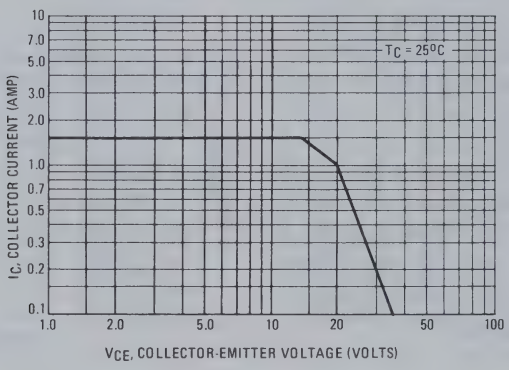


FIGURE 16 – DC SAFE OPERATING AREA



APPLICATIONS INFORMATION

The 2N6370 transistor is designed for linear power amplifier service in the driver or lower level stages of HF (2-30 MHz) single sideband (SSB) transmitters. It may also be used in amplitude modulated (AM) transmitters employing low level modulation in the exciter, or in any application requiring a linear amplifier. The device also has adequate gain for many VHF applications below 100 MHz.

Designed primarily for lower level stages and not the output stage of SSB transmitters, the 2N6370 does not employ internal emitter resistors. Therefore, for linear power amplifier applications which normally require forward bias for improved linearity, it is suggested that external emitter resistance be employed for improved DC operating point stability over the full temperature range. Typical resistor values for HF operation are illustrated in the test amplifier shown in Figure 1. The 2N6370 has more than adequate gain at HF, so the designer may wish to utilize unbypassed emitter resistance as shown in the circuit of Figure 1. Of course, bypassing may be included if more gain is desired.

The linear amplifier characterization data in Figures 2 through 10 were measured with the unbypassed emitter resistor configuration shown in Figure 1. For a more detailed discussion of linear power amplifier specifications and design, see Reference 1.

REFERENCES

1. "Solid-State Linear Power Amplifier Design", Motorola Semiconductor Products, Inc. Application Note AN-546
2. Pappenfus, Bruene, and Schoenike, "Single Sideband Principles and Circuits", McGraw – Hill.

2N6377 thru 2N6379 (SILICON)

HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

- High Collector Emitter Sustaining Voltage –
  $V_{CEO\ (sus)}$ = 80 Vdc (Min) – 2N6377
  = 100 Vdc (Min) – 2N6378
  = 120 Vdc (Min) – 2N6379
- High DC Current Gain –
  h_{FE} = 30-120 @ I_C = 20 Adc
  = 10 (Min) @ I_C = 50 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 20 Adc
- Fast Switching Times @ I_C = 20 Adc
  t_r = 0.35 μs (Max)
  t_s = 0.8 μs (Max)
  t_f = 0.25 μs (Max)

50 AMPERE
POWER TRANSISTORS
PNP SILICON
80, 100, 120 VOLTS
250 WATTS



* MAXIMUM RATINGS

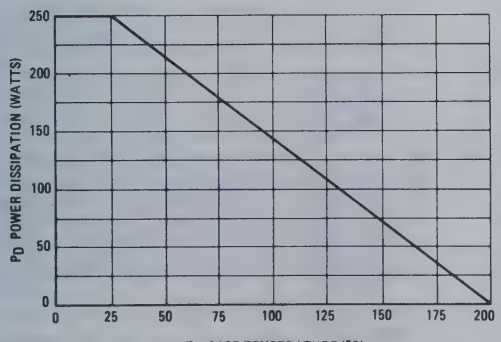
Rating	Symbol	2N6377	2N6378	2N6379	Unit
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Collector-Emitter Voltage	V_{CEO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current – Continuous	I_C	← 50 →			Adc
Peak		← 100 →			
Base Current	I_B	← 20 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 250 →			Watts
Derate above 25°C		← 1.43 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

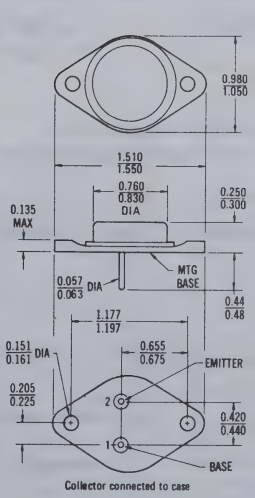
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





CASE 197

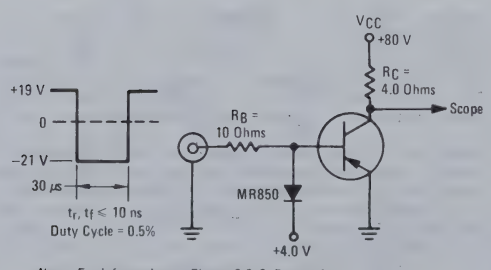
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N6380		80	–	
	2N6381		100	–	
	2N6382		120	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6380		–	50	
(V_{CE} = 60 Vdc, I_B = 0)	2N6381		–	50	
(V_{CE} = 70 Vdc, I_B = 0)	2N6382		–	50	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 90% Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	10	μAdc
(V_{CE} = 90% Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	1.0	mAdc
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{EB} = 6.0 Vdc, I_C = 0)					
***ON CHARACTERISTICS** (1)					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			50	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)			30	120	
(I_C = 50 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	–		Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.2	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.8	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.5	
DYNAMIC CHARACTERISTICS					
*Current-Gain – Bandwidth Product (2)		f_T	30	–	MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)					
Input Capacitance		C_{ib}			pF
(V_{EB} = 2.0 Vdc, I_C = 0, f = 0.1 MHz)			–	7000	
*Output Capacitance		C_{ob}	–	1500	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
***SWITCHING CHARACTERISTICS** (Figure 2)					
Rise Time	(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)	t_r	–	0.35	μs
Storage Time		t_s	–	0.80	μs
Fall Time		t_f	–	0.25	μs

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%. (2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



Note: For information on Figures 3 & 6, R_B and R_C were varied to obtain desired test conditions.

FIGURE 3 – TURN ON TIME

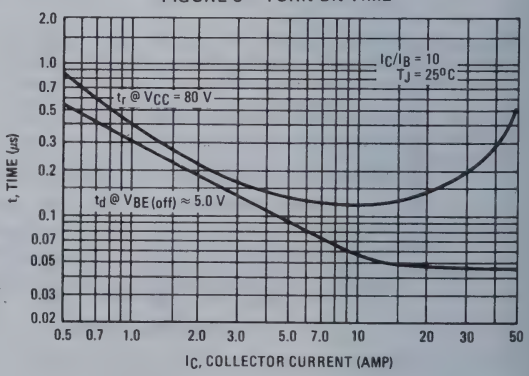


FIGURE 4 – THERMAL RESPONSE

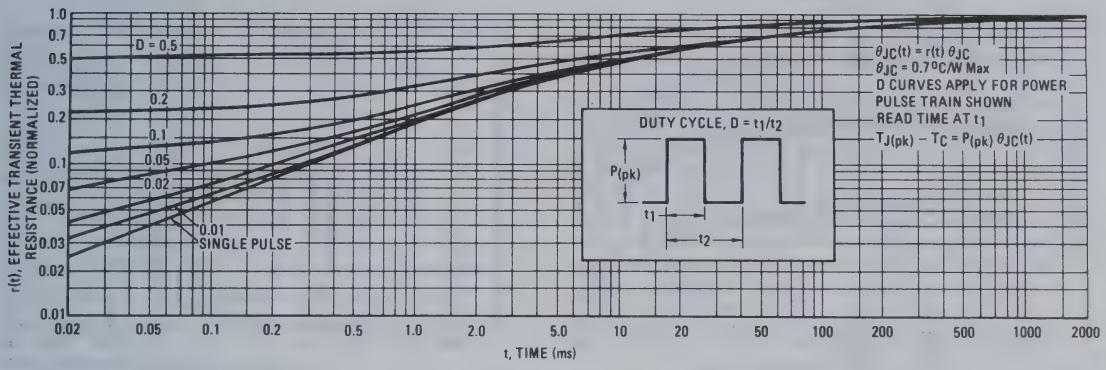
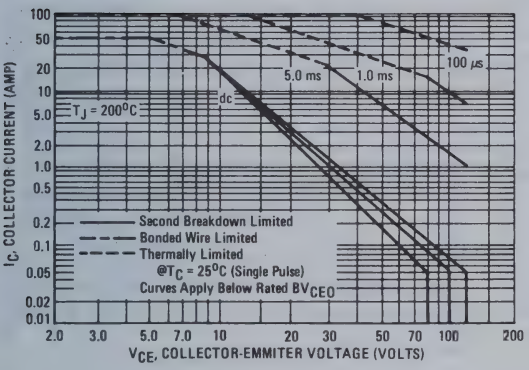


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

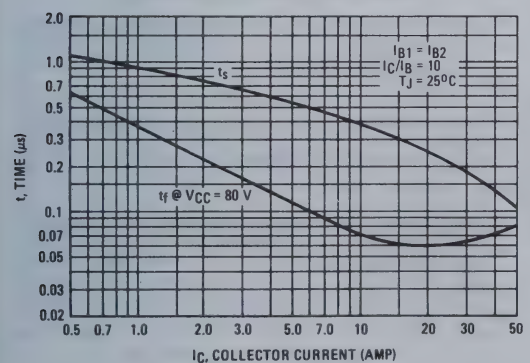


FIGURE 7 – CAPACITANCE

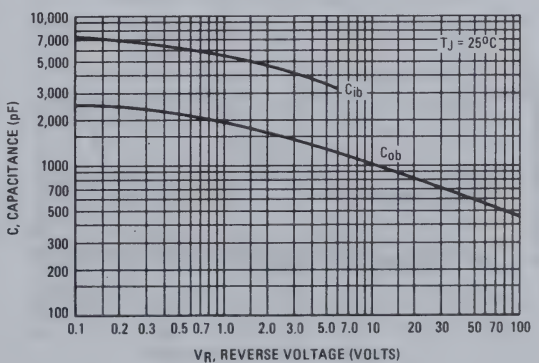


FIGURE 8 – DC CURRENT GAIN

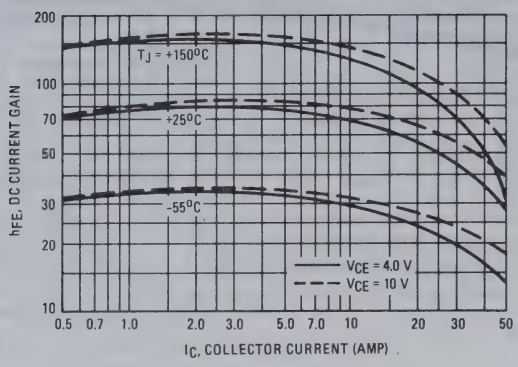


FIGURE 9 – COLLECTOR SATURATION REGION

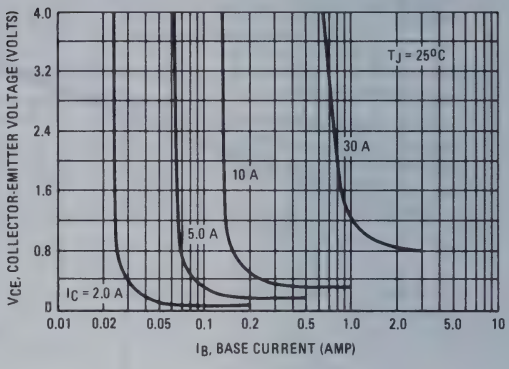


FIGURE 10 – "ON" VOLTAGES

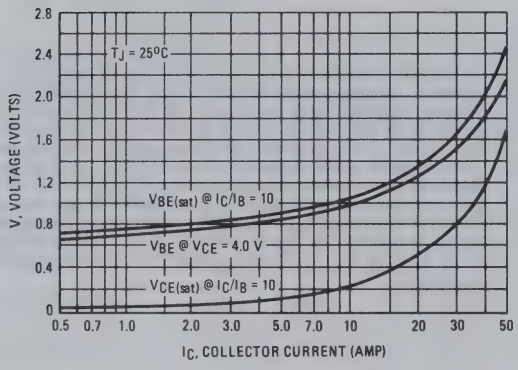


FIGURE 11 – TEMPERATURE COEFFICIENTS

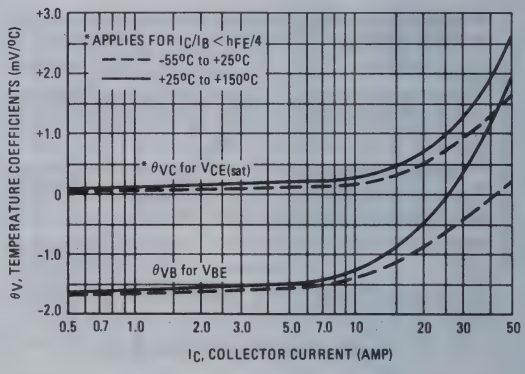


FIGURE 12 – COLLECTOR CUT-OFF REGION

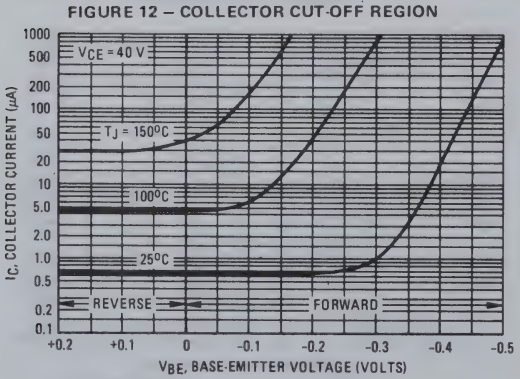
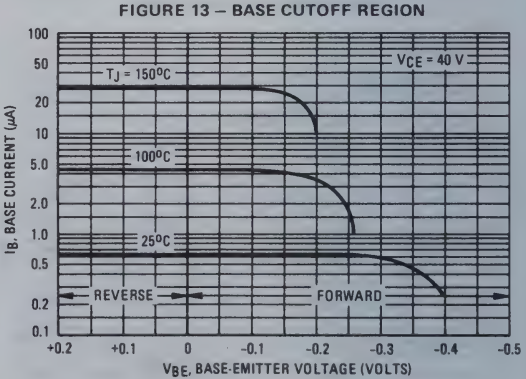


FIGURE 13 – BASE CUTOFF REGION



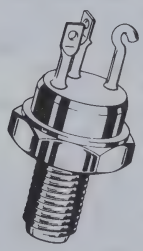
2N6380 thru 2N6382 (SILICON)

HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in industrial-military power amplifier and switching circuit applications.

- High Collector Emitter Sustaining Voltage –
  $V_{CEO\ (sus)}$ = 80 Vdc (Min) – 2N6380
  = 100 Vdc (Min) – 2N6381
  = 120 Vdc (Min) – 2N6382
- High DC Current Gain –
  h_{FE} = 30-120 @ I_C = 20 Adc
  = 10 (Min) @ I_C = 50 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 20 Adc
- Fast Switching Times @ I_C = 20 Adc
  t_r = 0.35 μs (Max)
  t_s = 0.8 μs (Max)
  t_f = 0.25 μs (Max)

50 AMPERE
POWER TRANSISTORS
PNP SILICON
80, 100, 120 VOLTS
250 WATTS



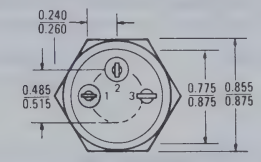
*MAXIMUM RATINGS

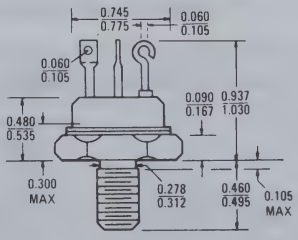
Rating	Symbol	2N6380	2N6381	2N6382	Unit
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Collector-Emitter Voltage	V_{CEO}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current – Continuous	I_C	← 50 →			Adc
Peak		← 100 →			
Base Current	I_B	← 20 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 250 →			Watts
Derate above 25°C		← 1.43 →			W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← −65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.70	°C/W

*Indicates JEDEC Registered Data.

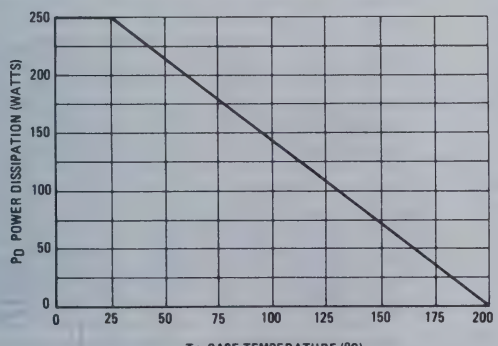




PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 188
TO-63
Collector connected to case.

FIGURE 1 – POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

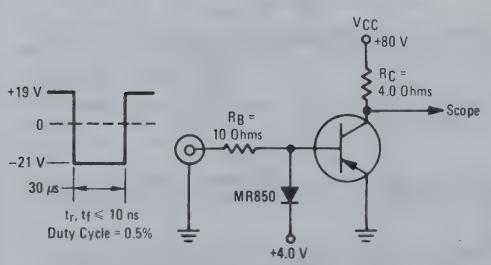
Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	2N6380	$V_{CEO(sus)}$	80	–	Vdc
	2N6381		100	–	
	2N6382		120	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N6380		–	50	
(V_{CE} = 60 Vdc, I_B = 0)	2N6381		–	50	
(V_{CE} = 70 Vdc, I_B = 0)	2N6382		–	50	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 90% Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)			–	10	μAdc
(V_{CE} = 90% Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			–	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
***ON CHARACTERISTICS** (1)					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			50	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)			30	120	
(I_C = 50 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$	–		Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.2	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.8	
(I_C = 50 Adc, I_B = 10 Adc)			–	3.5	
DYNAMIC CHARACTERISTICS					
*Current-Gain — Bandwidth Product (2) (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	30	–	MHz
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 0.1 MHz)		C_{ib}	–	7000	pF
*Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	1500	pF
*** SWITCHING CHARACTERISTICS** (Figure 2)					
Rise Time	(V_{CC} = 80 Vdc, I_C = 20 Adc, I_{B1} = I_{B2} = 2.0 Adc)	t_r	–	0.35	μs
Storage Time		t_s	–	0.80	μs
Fall Time		t_f	–	0.25	μs

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



Note: For information on Figures 3 & 6, R_B and R_C were varied to obtain desired test conditions.

FIGURE 3 – TURN ON TIME

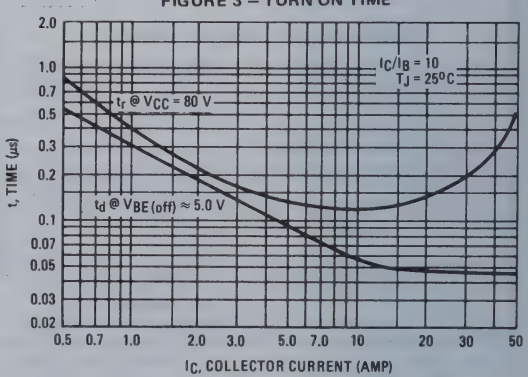


FIGURE 4 – THERMAL RESPONSE

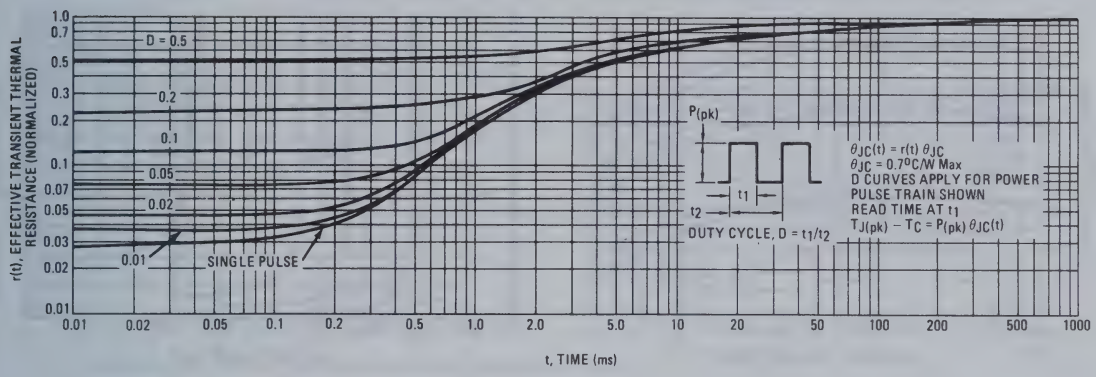
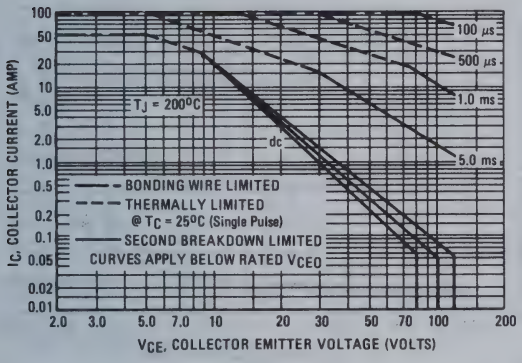


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

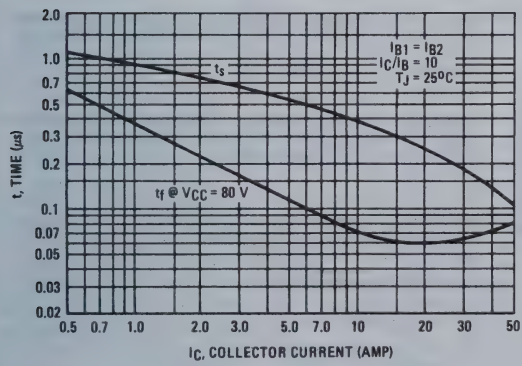


FIGURE 7 – CAPACITANCE

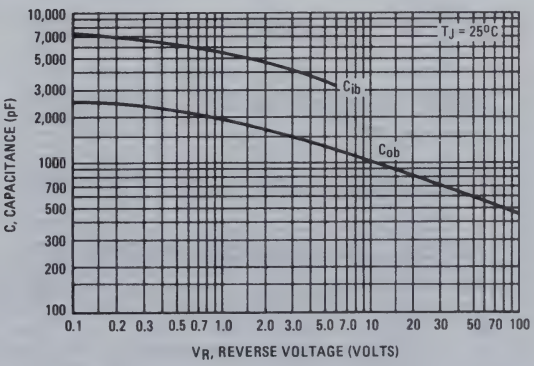


FIGURE 8 – DC CURRENT GAIN

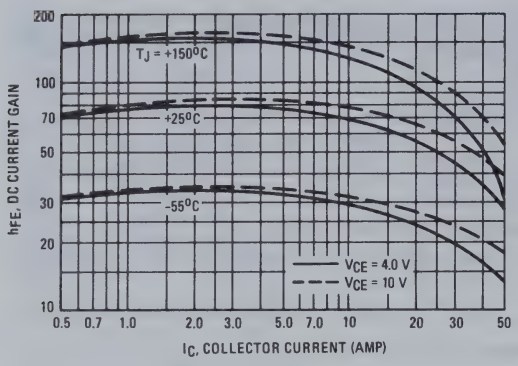


FIGURE 9 – COLLECTOR SATURATION REGION

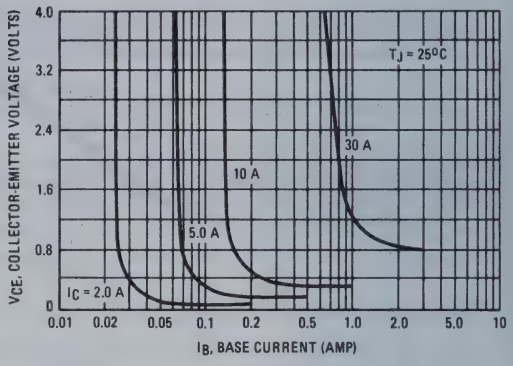


FIGURE 10 – "ON" VOLTAGES

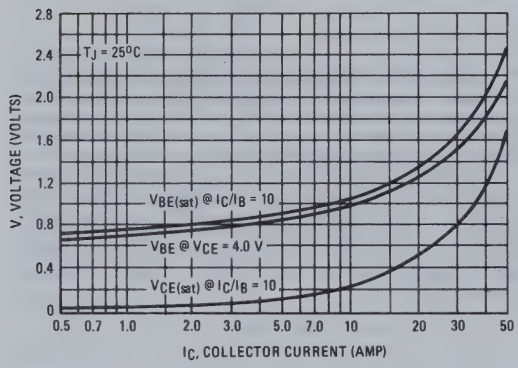


FIGURE 11 – TEMPERATURE COEFFICIENTS

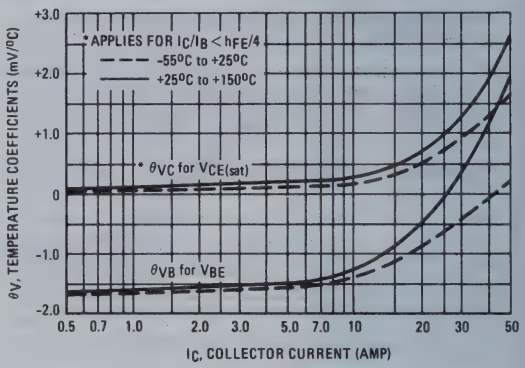


FIGURE 12 – COLLECTOR CUT-OFF REGION

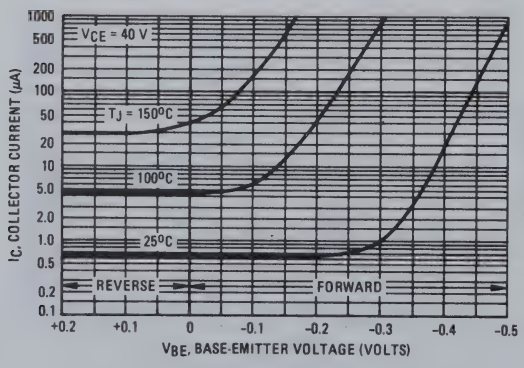
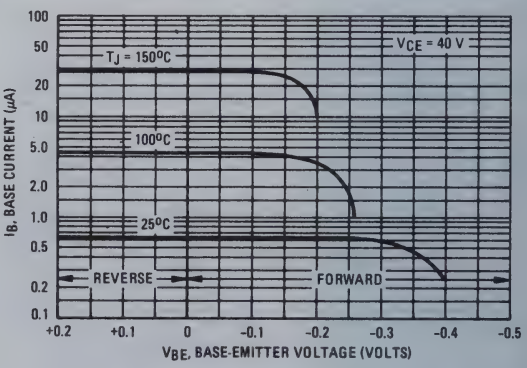


FIGURE 13 – BASE CUT-OFF REGION



2N6394 thru 2N6399 (SILICON)



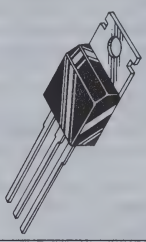
THYRISTORS

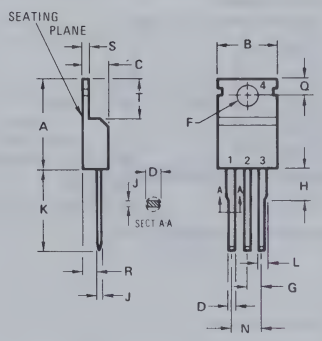
12 AMPERES RMS
50-800 VOLTS

SILICON CONTROLLED RECTIFIERS

. . . designed primarily for half-wave ac control applications, such as motor controls, heating controls and power supplies; or wherever half-wave silicon gate-controlled, solid-state devices are needed.

- Glass Passivated Junctions and Center Gate Fire for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermowatt Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Blocking Voltage to 800 Volts





PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

All JEDEC dimensions and notes apply

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.29	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.31	1.14	0.012	0.045
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	0.51	1.39	0.020	0.055
T	5.85	6.85	0.230	0.270

CASE 221-02
TO 220 AB

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
2N6394		50	
2N6395		100	
2N6396		200	
2N6397		400	
2N6398		600	
2N6399		800	
Forward Current RMS T_J = 125°C (All Conduction Angles)	$I_{T(RMS)}$	12	Amps
Peak Forward Surge Current (1/2 cycle, Sine Wave, 60 Hz, T_J = 125°C)	I_{TSM}	100	Amps
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Forward Peak Gate Power	P_{GM}	20	Watts
Forward Average Gate Power	$P_{G(AV)}$	0.5	Watt
Forward Peak Gate Current	I_{GM}	2.0	Amps
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage supplied exceeds the rated blocking voltage.

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
* Peak Forward Blocking Voltage (T_J = 125°C)	2N6394	V_{DRM}	50	–	–	Volts
	2N6395		100	–	–	
	2N6396		200	–	–	
	2N6397		400	–	–	
	2N6398		600	–	–	
	2N6399		800	–	–	
* Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 125°C)		I_{DRM}	–	–	2.0	mA
* Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 125°C)		I_{RRM}	–	–	2.0	mA
* Forward "On" Voltage (I_{TM} = 24 A Peak)		V_{TM}	–	1.7	2.2	Volts
* Gate Trigger Current (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 100 Ohms)		I_{GT}	–	5.0	30	mA
* Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 100 Ohms)		V_{GT}	–	0.7	1.5	Volts
* Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms, T_J = 125°C)		V_{GD}	0.2	–	–	Volts
* Holding Current (Anode Voltage = 12 Vdc)		I_H	–	6.0	40	mA
Turn-On Time (I_{TM} = 12 A, I_{GT} = 40 mAdc)		t_{gt}	–	1.0	2.0	μs
Turn-Off Time (V_{DRM} = rated voltage)		tq				μs
(I_{TM} = 12 A, I_R = 12 A)			–	15	–	
(I_{TM} = 12 A, I_R = 12 A, T_J = 125°C)			–	35	–	
Forward Voltage Application Rate (T_J = 125°C)		dv/dt	–	50	–	V/μs

*Indicates JEDEC Registered Data.

FIGURE 1 – AVERAGE CURRENT DERATING

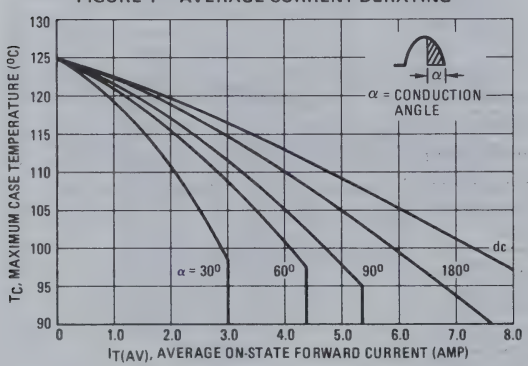


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION

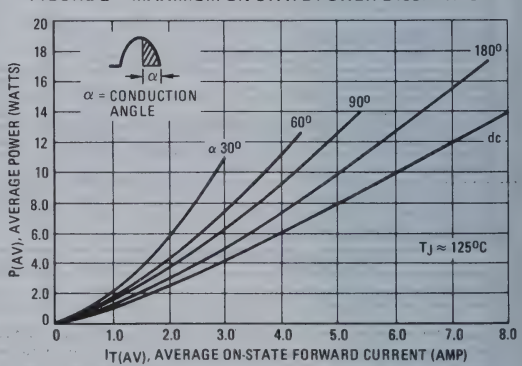


FIGURE 3 – MAXIMUM ON-STATE CHARACTERISTICS

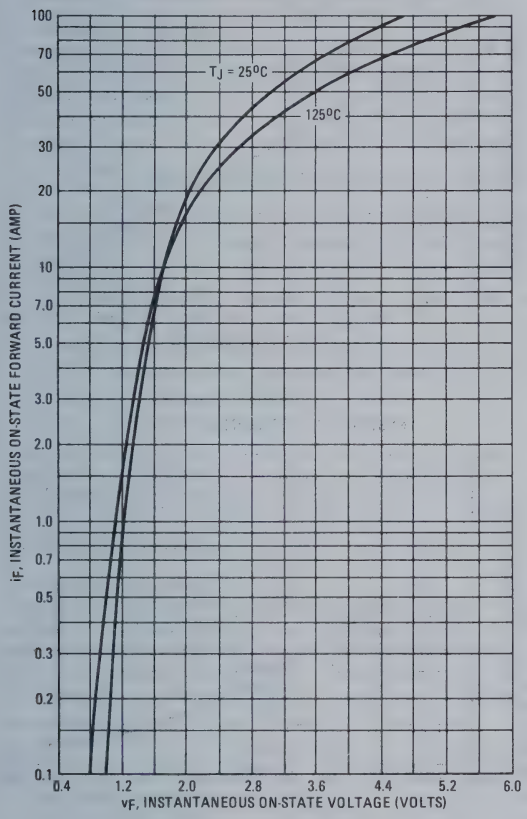


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CURRENT

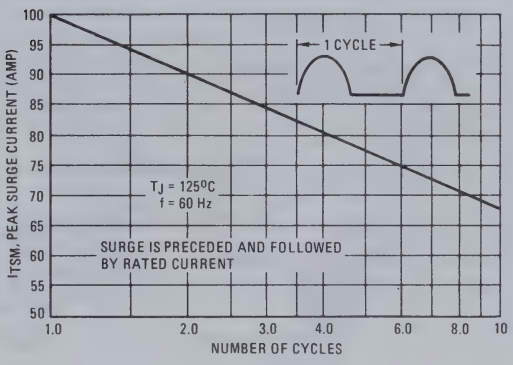


FIGURE 5 – CHARACTERISTICS AND SYMBOLS

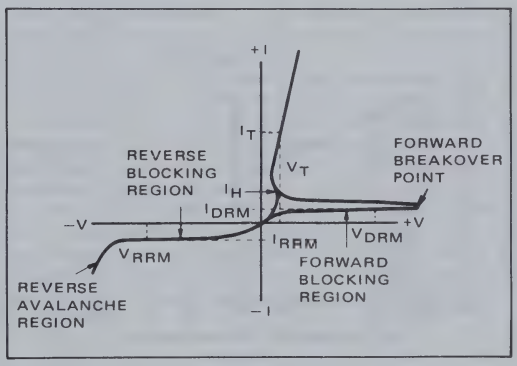
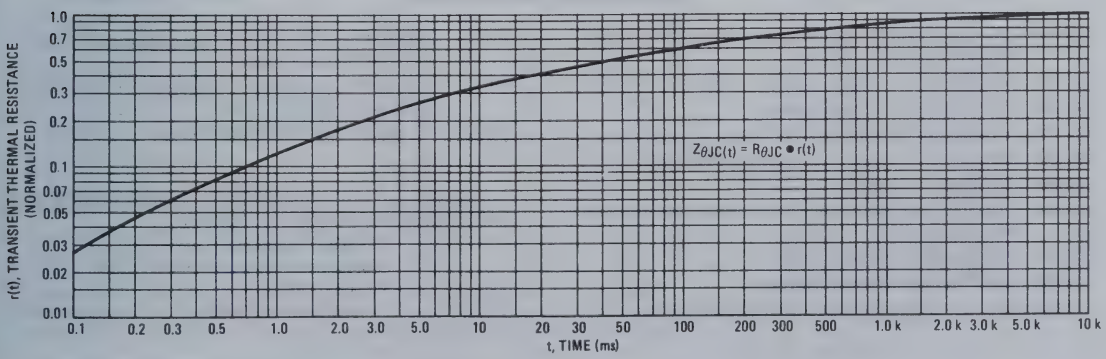


FIGURE 6 – THERMAL RESPONSE



TYPICAL CHARACTERISTICS

FIGURE 7 – PULSE TRIGGER CURRENT

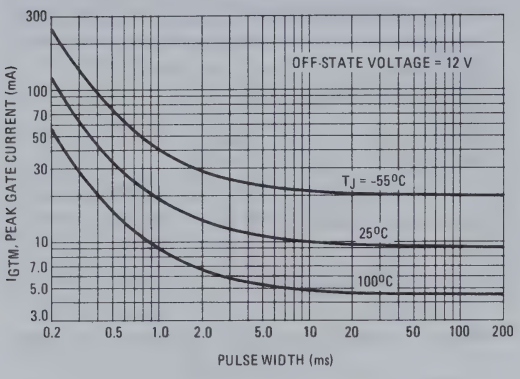


FIGURE 8 – GATE TRIGGER CURRENT

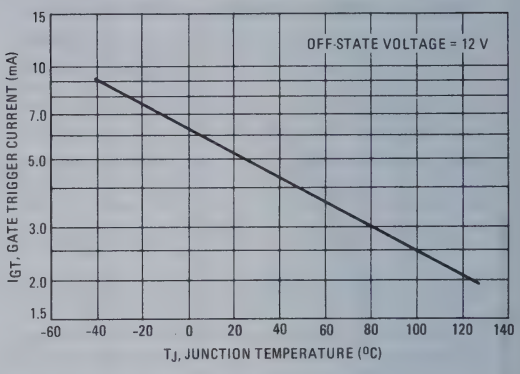


FIGURE 9 – GATE TRIGGER VOLTAGE

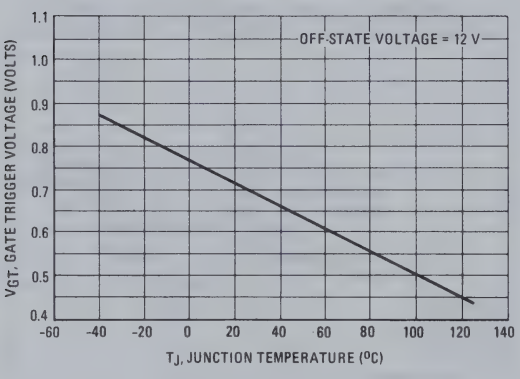
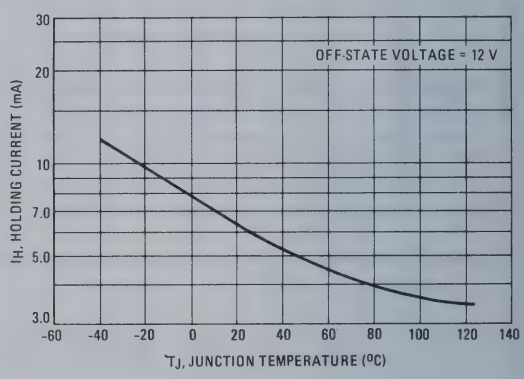


FIGURE 10 – HOLDING CURRENT



THYRISTER APPLICATION NOTES

AN-140 Characterization of SCR's as Switches for Line Type Modulators

AN-189 Solid-State Pulse Width Modulation DC Motor Control

AN-240 SCR Power Control Fundamentals

AN-295 Suppressing RFI in Thyristor Circuits

AN-413 Unijunction Trigger Circuits for Gated Thyristors

AN-441 SCR Slaving Circuits

AN-443 Directional and Speed Control for Series, Universal and Shunt Motors

AN-450 Induction Motor Speed Control

AN-453 Zero Point Switching Techniques

AN-482 Electronic Speed Control of Appliance Motors

AN-526 Theory, Characteristics and Applications of Silicon Unilateral and Bilateral Switches

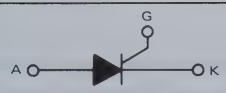
AN-527 Theory, Characteristics and Applications of the Programmable Unijunction Transistor

AN-568 A Fuse-Thyristor Coordinator Primer

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2N6400 thru 2N6405 (SILICON)



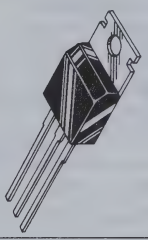
THYRISTORS

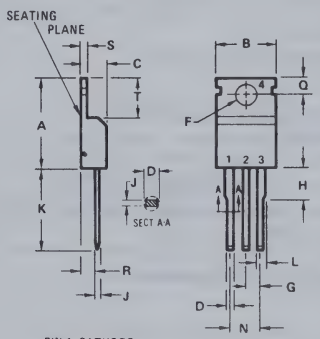
16 AMPERES RMS
50-800 VOLTS

SILICON CONTROLLED RECTIFIERS

. . . designed primarily for half-wave ac control applications, such as motor controls, heating controls and power supplies; or wherever half-wave silicon gate-controlled, solid-state devices are needed.

- Glass Passivated Junctions with Center Gate Fire for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermowatt Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Blocking Voltage to 800 Volts





PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

All JEDEC dimensions and notes apply

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.23	15.87	0.560	0.625
B	9.66	10.66	0.380	0.420
C	3.56	4.82	0.140	0.190
D	0.51	1.14	0.020	0.045
F	3.531	3.733	0.139	0.147
G	2.28	2.79	0.090	0.110
H	—	6.35	—	0.250
J	0.31	1.14	0.012	0.045
K	12.70	14.27	0.500	0.562
L	1.14	1.77	0.045	0.070
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.92	0.080	0.115
S	0.51	1.39	0.020	0.055
T	5.85	6.85	0.230	0.270

CASE 221-02
TO 220 AB

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
2N6400		50	
2N6401		100	
2N6402		200	
2N6403		400	
2N6404		600	
2N6405		800	
Forward Current RMS (T_C = 90°C) (All Conduction Angles)	$I_{T(RMS)}$	16	Amps
Peak Forward Surge Current (1/2 cycle, Sine Wave, 60 Hz, T_J = 125°C)	I_{TSM}	160	Amps
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	100	A^2s
Forward Peak Gate Power	P_{GM}	20	Watts
Forward Average Gate Power	$P_{G(AV)}$	0.5	Watt
Forward Peak Gate Current	I_{GM}	2.0	Amps
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage supplied exceeds the rated blocking voltage.

*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (T_J = 125°C)		V_{DRM}				Volts
	2N6400		50	–	–	
	2N6401		100	–	–	
	2N6402		200	–	–	
	2N6403		400	–	–	
	2N6404		600	–	–	
	2N6405		800	–	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 125°C)		I_{DRM}	–	–	2.0	mA
*Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 125°C)		I_{RRM}	–	–	2.0	mA
*Forward "On" Voltage (I_{TM} = 32 A peak)		V_{TM}	–	–	1.7	Volts
*Gate Trigger Current (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 100 Ohms)		I_{GT}	–	5.0	30	mA
*Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 100 Ohms)		V_{GT}	–	0.7	1.5	Volts
*Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms, T_J = 125°C)		V_{GD}	0.2	–	–	Volts
*Holding Current (Anode Voltage = 12 Vdc)		I_H	–	6.0	40	mA
Turn-On Time (I_{TM} = 16 A, I_{GT} = 40 mAdc)		t_{gt}	–	1.0	–	μs
Turn-Off Time (V_{DRM} = rated voltage)		t_q				μs
(I_{TM} = 16 A, I_R = 16 A)			–	15	–	
(I_{TM} = 16 A, I_R = 16 A, T_J = 125°C)			–	35	–	
Forward Voltage Application Rate (T_J = 125°C)		dv/dt	–	50	–	V/μs

*Indicates JEDEC Registered Data.

FIGURE 1 – AVERAGE CURRENT DERATING

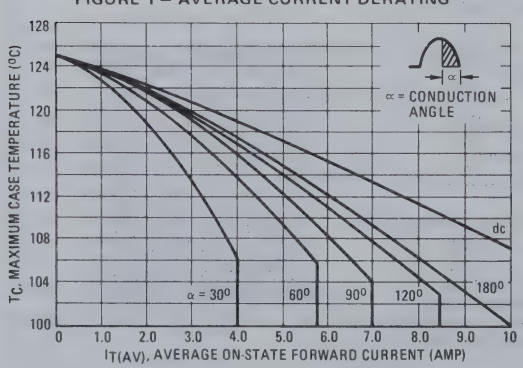


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION

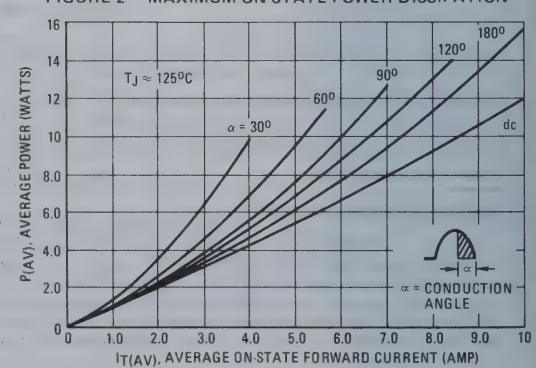


FIGURE 3 – MAXIMUM ON-STATE CHARACTERISTICS

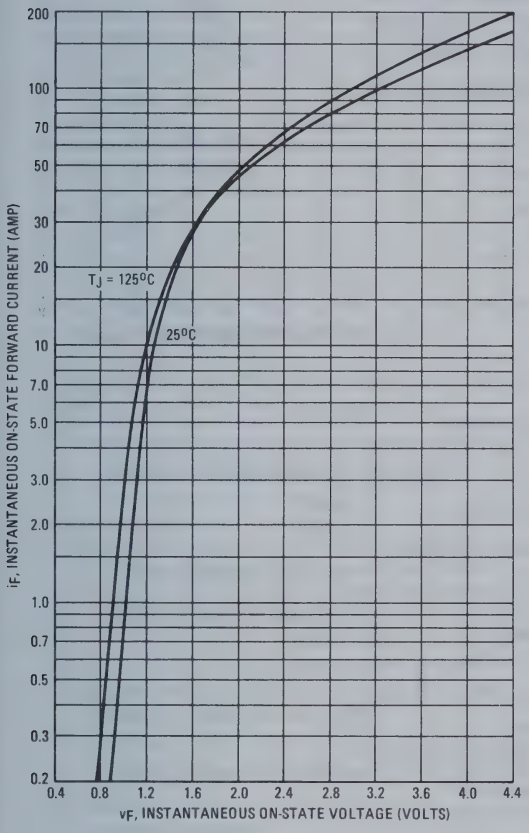


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CURRENT

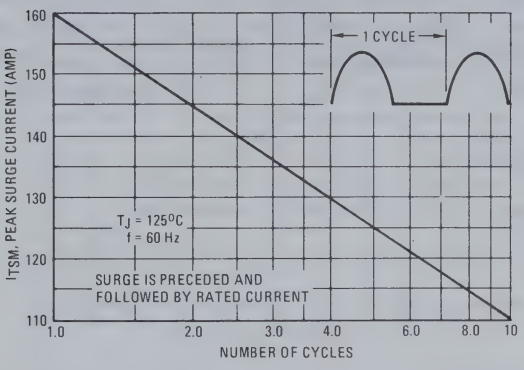


FIGURE 5 – CHARACTERISTICS AND SYMBOLS

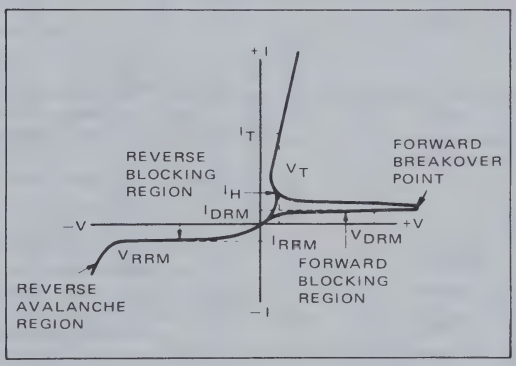
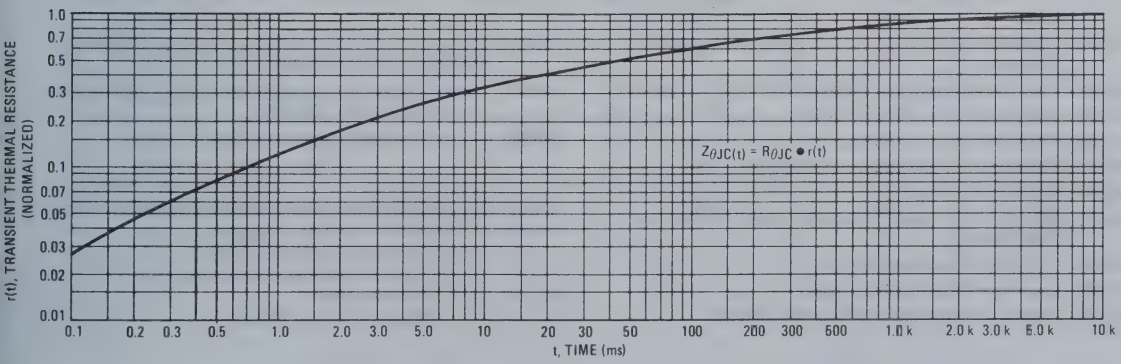


FIGURE 6 – THERMAL RESPONSE



TYPICAL TRIGGER CHARACTERISTICS

FIGURE 7 – GATE TRIGGER CURRENT

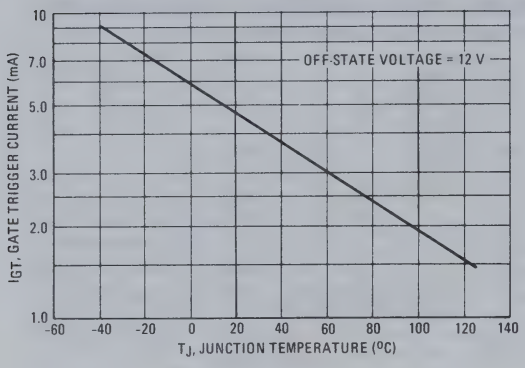


FIGURE 8 – GATE TRIGGER VOLTAGE

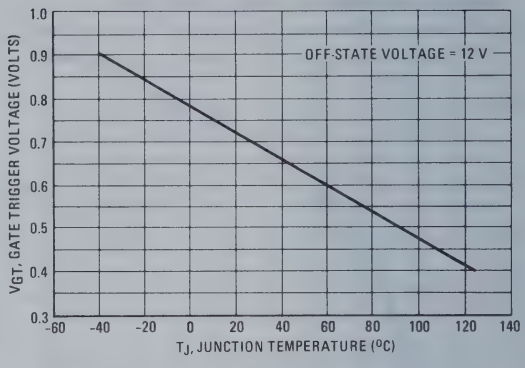
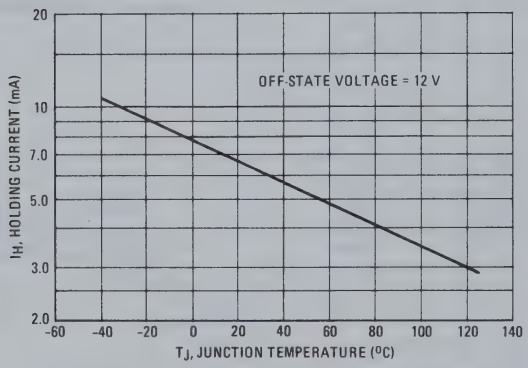


FIGURE 9 – HOLDING CURRENT



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3N124 (SILICON)
3N125
3N126



CASE 20(4)
TO-72

N-channel silicon annular tetrode-connected field-effect transistors, designed for low-power switching and amplifier applications in the audio through VHF frequency range, features high breakdown voltage, low transfer capacitance, and tetrode configuration for a broad range of applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Gate-Source Voltage			Vdc
Gate 1	V_{G1S}	50	
Gate 2	V_{G2S}	50	
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage			Vdc
Gate 1	V_{DG1}	50	
Gate 2	V_{DG2}	50	
Gate 1-Gate 2 Current	I_{G1G2}	1.0	mAdc
Gate 2-Gate 1 Current	I_{G2G1}	1.0	mAdc
Gate Current			mAdc
Gate 1	I_{G1}	20	
Gate 2	I_{G2}	20	
Drain Current	I_D	20	mAdc
Junction Operating Temperature	T_J	175	^oC
Storage Temperature Range	T_{stg}	-65 to +175	^oC
Total Device Dissipation @ $T_A = 25^oC$	P_D	300	mW
Derate Above 25^oC		1.71	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	800	mW
Derate Above 25^oC		4.57	$mW/^oC$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0, V_{G1G2} = 0)		$V_{(BR)GSS}$	50	-	Vdc
Gate Reverse Current (V_{GS} = 25 Vdc, V_{DS} = 0, V_{G1G2} = 0)		I_{GSS}	-	0.250	nAdc
(V_{GS} = 25 Vdc, V_{DS} = 0, V_{G1G2} = 0, T_A = +150°C)			-	250	
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1G2} = 0, V_{GS} = 0)	3N124	I_{DSS}	0.2	2.0	mAdc
	3N125		1.5	4.5	
	3N126		3.0	9.0	
Gate-Source Voltage (I_D = 20 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N124	V_{GS}	0.2	2.0	Vdc
(I_D = 150 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N125		1.0	3.0	
(I_D = 300 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N126		1.5	5.5	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G1G2} = 0)	3N124	$V_{GS(off)}$	-	-2.5	Vdc
	3N125		-	-4.0	
	3N126		-	-6.5	
Gate 1-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G2S} = 0)	3N124	$V_{G1S(off)}$	-	-5.0	Vdc
	3N125		-	-8.0	
	3N126		-	-18	
Gate 2-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G1S} = 0)	3N124	$V_{G2S(off)}$	-	-8.0	Vdc
	3N125		-	-14	
	3N126		-	-26	
Gate 1-Gate 2 Reach Through Voltage (I_{G1G2} = 10 μAdc, I_S = 0, I_D = 0)	3N124	V_{G1G2}	1.0	-	Vdc
	3N125		3.0	-	
	3N126		5.0	-	
Gate 2-Gate 1 Reach Through Voltage (I_{G2G1} = 10 μAdc, I_S = 0, I_D = 0)	3N124	V_{G2G1}	2.0	-	Vdc
	3N125		6.0	-	
	3N126		10	-	
Gate 1-Gate 2 Reach Through Drain Current (V_{DS} = 15 Vdc, I_{G1} = 10 μAdc, V_{G2S} = 0)		I_D	-	1.0	μAdc
Gate 2-Gate 1 Reach Through Drain Current (V_{DS} = 15 Vdc, I_{G2} = 10 μAdc, V_{G1S} = 0)		I_D	-	1.0	μAdc

SMALL-SIGNAL COMMON-SOURCE CHARACTERISTICS

Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					μmhos
Gate 1-Gate 2	3N124	$\lvert y_{fs} \rvert$	500	2000	
	3N125		800	2400	
	3N126		1200	3600	
Gate 1 Only	3N124	$\lvert y_{fs1} \rvert$	250	1000	
	3N125		400	1600	
	3N126		600	2700	
Gate 2 Only	3N124	$\lvert y_{fs2} \rvert$	200	800	
	3N125		250	1000	
	3N126		400	1200	
(V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 100 MHz)					
Gate 1 Only	3N124	$\lvert y_{fs1} \rvert$	250	-	
	3N125		400	-	
	3N126		600	-	
Output Admittance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)	3N124	y_{os}	-	2.0	μmhos
	3N125		-	10	
	3N126		-	20	
Input Capacitance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					pF
Gate 1-Gate 2		C_{iss}	-	14	
Gate 1 Only		C_{iss1}	-	5.0	
Gate 2 Only		C_{iss2}	-	9.0	
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					pF
Gate 1-Gate 2		C_{rss}	-	2.0	
Gate 1 Only		C_{rss1}	-	0.5	
Gate 2 Only		C_{rss2}	-	1.5	
Spot Noise Figure (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, R_S = 1.0 megohm, f = 1.0 kHz, BW = 100 Hz)		NF	-	4.0	dB
			Typ		
Static Drain-Source "ON" Resistance (V_{GS} = 0, V_{DS} = 0)	3N124	$r_{DS(on)}$	1000		ohms
	3N125		750		
	3N126		500		

FIGURE 1 — DRAIN CURRENT versus GATE SOURCE VOLTAGE

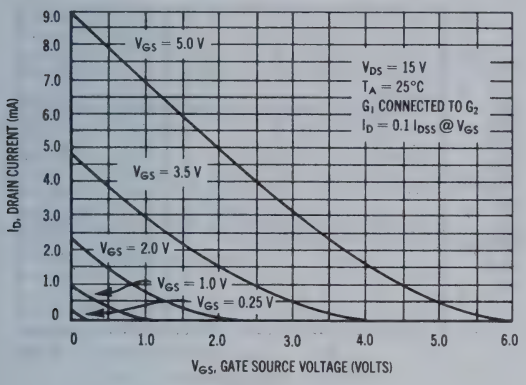


FIGURE 2 — PARAMETER INTER-RELATIONSHIPS

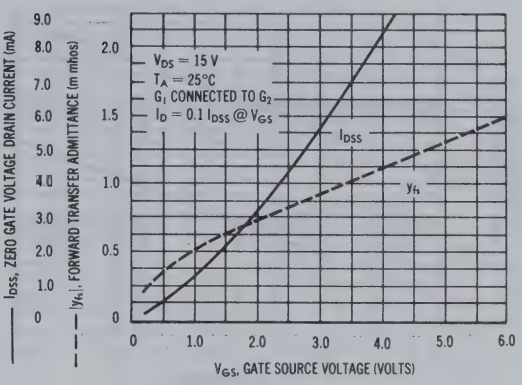


FIGURE 3 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

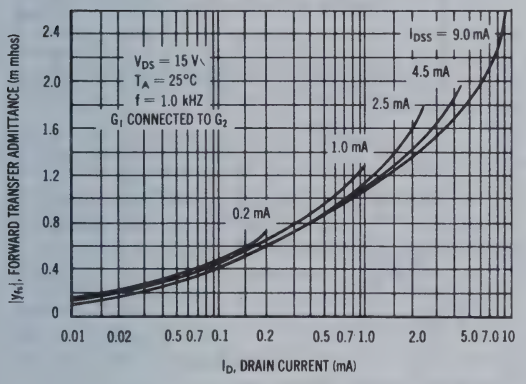
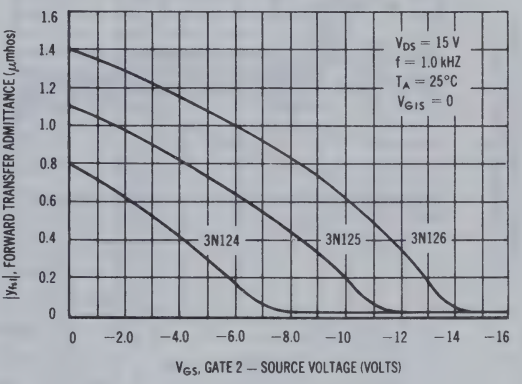


FIGURE 4 GATE 1 — FORWARD TRANSFER ADMITTANCE versus GATE 2 — SOURCE VOLTAGE



NOISE CHARACTERISTICS

V_{DS} = 15 Vdc, I_D = I_{DSS}, T_A = 25°C
GATE 1 CONNECTED TO GATE 2

FIGURE 5A — FREQUENCY VARIATIONS

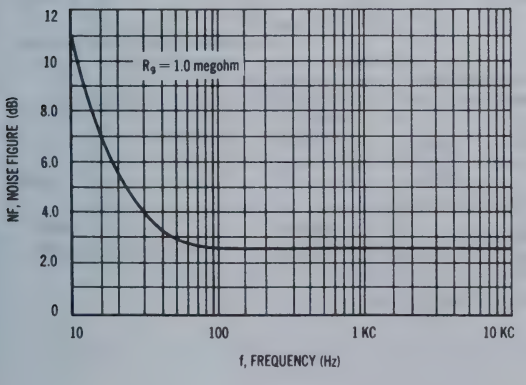
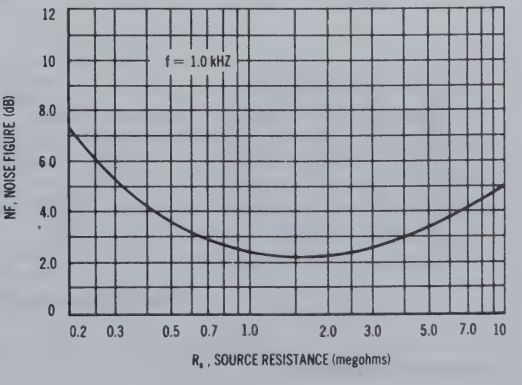


FIGURE 5B — SOURCE RESISTANCE VARIATIONS



HIGH FREQUENCY y PARAMETER CHARACTERISTICS

V_{DS} = 15 Vdc, V_{GS} = 0, T_A = 25°C — GATE 2 CONNECTED TO SOURCE

FIGURE 6 — INPUT ADMITTANCE

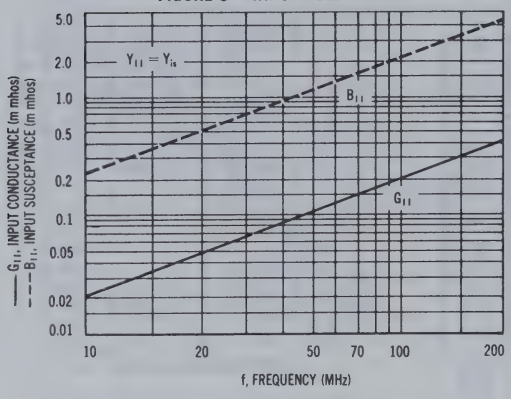


FIGURE 7 — REVERSE TRANSFER ADMITTANCE

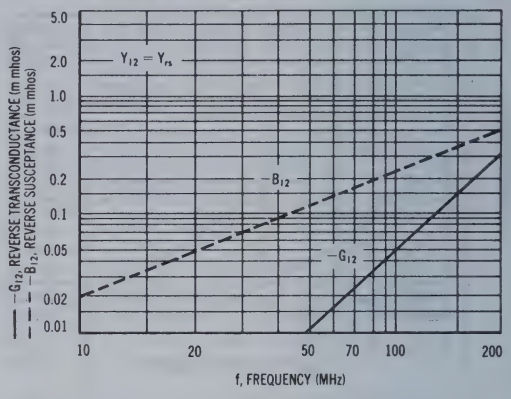


FIGURE 8 — FORWARD TRANSFER ADMITTANCE

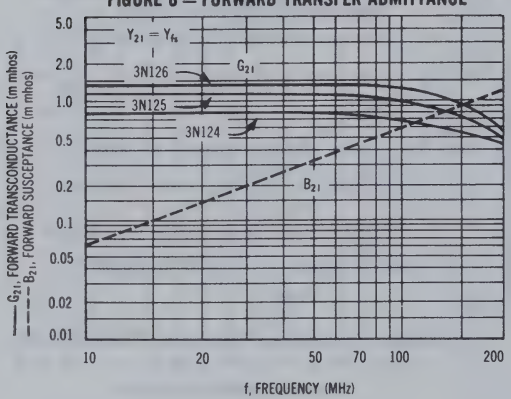
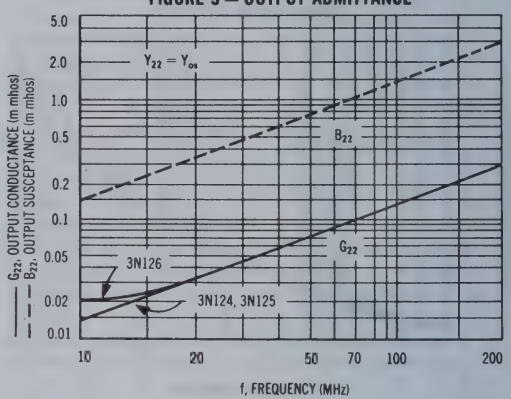
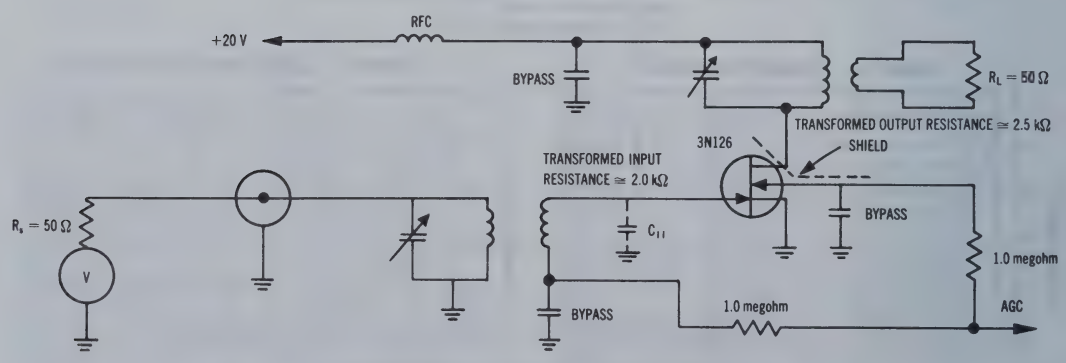


FIGURE 9 — OUTPUT ADMITTANCE



TYPICAL PERFORMANCE USING THE 3N126



CIRCUIT POWER GAIN = 8.0 dB* TYPICAL AT 105 MHz (AGC = 0V)

*Includes circuit losses.

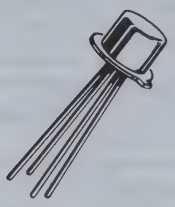
3N128 (SILICON)

SILICON N-CHANNEL MOS FIELD-EFFECT TRANSISTOR

. . . designed for VHF amplifier and oscillator applications in communications equipment.

- High Forward Transadmittance — $|y_{fs}|$ = 5000 μmhos (Min) @ f = 1.0 kHz
- Low Input Capacitance — C_{iss} = 7.0 pF (Max) @ f = 1.0 MHz
- Low Noise Figure — NF = 5.0 dB (Max) @ f = 200 MHz
- High Power Gain — P_G = 13.5 dB (Min) @ f = 200 MHz
- Complete "y" Parameter Curves
- Third Order Intermodulation Distortion Performance Curve Provided

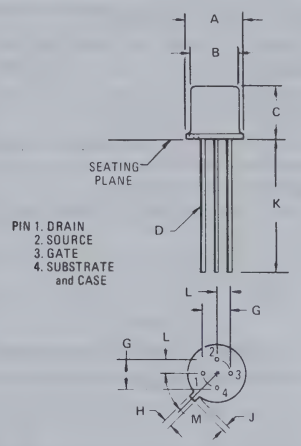
N-CHANNEL MOS FIELD-EFFECT TRANSISTOR



* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+20	Vdc
Drain-Gate Voltage	V_{DG}	+20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	50	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 2.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.310	5.840	0.209	0.230
B	4.520	4.950	0.178	0.195
C	4.320	5.330	0.170	0.210
D	0.406	0.483	0.016	0.019
G	0.254 TYP		0.100 TYP	
H	0.914	1.140	0.036	0.045
J	0.711	1.220	0.028	0.048
K	12.700	-	0.500	-
L	1.270 TYP		0.050 TYP	
M	45° TYP		45° TYP	

All JEDEC dimensions and notes apply

CASE 20(7)
TO-72

HANDLING PRECAUTIONS

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-50	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	$V_{GS(off)}$	-0.5	-8.0	Vdc
Gate Reverse Current	I_{GSS}			nAdc
(V_{GS} = -8.0 Vdc, V_{DS} = 0)		–	0.05	
(V_{GS} = -8.0 Vdc, V_{DS} = 0, T_A = 125°C)		–	5.0	
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	25	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	5000	12,000	μmhos
Forward Transconductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{fs})$	5000	–	μmhos
Output Conductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{os})$	–	500	μmhos
Input Conductance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	$Re(y_{is})$	–	800	μmhos
Input Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{iss}	–	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 MHz)	C_{rss}	–	0.28	pF
Noise Figure (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	NF	–	5.0	dB
Power Gain (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 200 MHz)	P_G	13.5	—	dB

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

TYPICAL CHARACTERISTICS

(T_A = 25°C)

FIGURE 1 – DRAIN CHARACTERISTICS

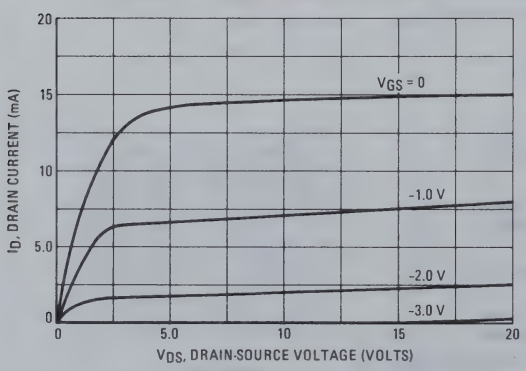
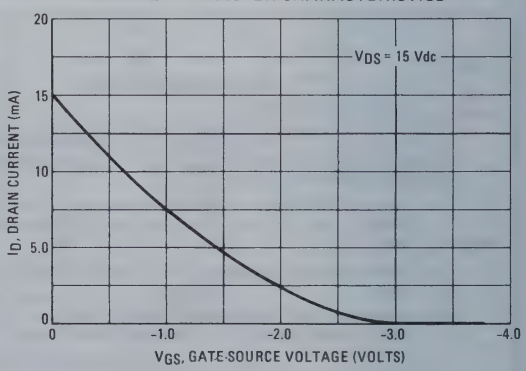


FIGURE 2 – TRANSFER CHARACTERISTICS



TYPICAL 1 kHz DRAIN CHARACTERISTICS

(T_A = 25°C, V_{DS} = 15 Vdc, f = 1.0 kHz)

FIGURE 3 – FORWARD TRANSADMITTANCE versus GATE BIAS VOLTAGE

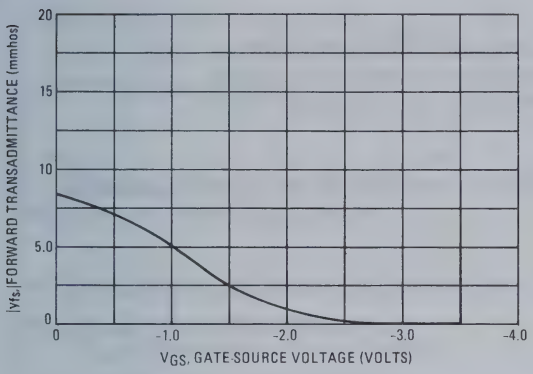
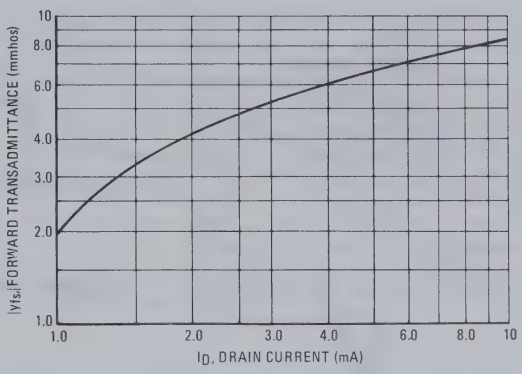


FIGURE 4 – FORWARD TRANSADMITTANCE versus DRAIN CURRENT



TYPICAL 200 MHz COMMON-SOURCE ADMITTANCE CHARACTERISTICS

(T_A = 25°C, V_{DS} = 15 Vdc, f = 200 MHz)

FIGURE 5 – INPUT ADMITTANCE (y_{is}) COMPONENTS

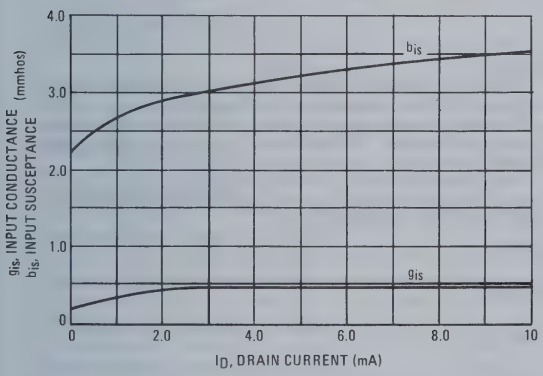


FIGURE 6 – FORWARD TRANSADMITTANCE (y_{fs}) COMPONENTS

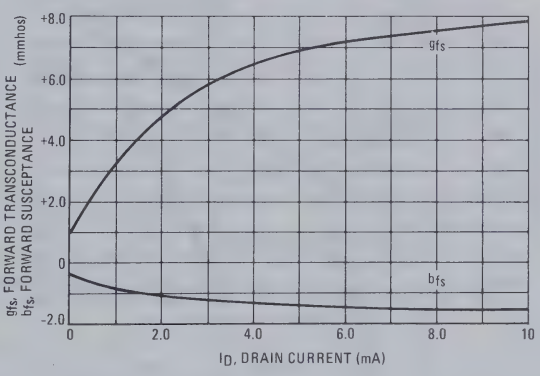


FIGURE 7 – REVERSE TRANSADMITTANCE (y_{rs}) COMPONENTS

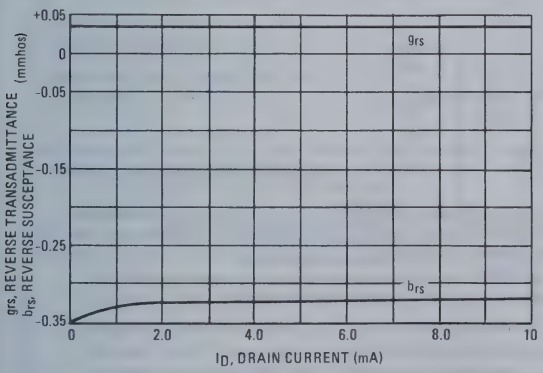


FIGURE 8 – OUTPUT ADMITTANCE (y_{os}) COMPONENTS

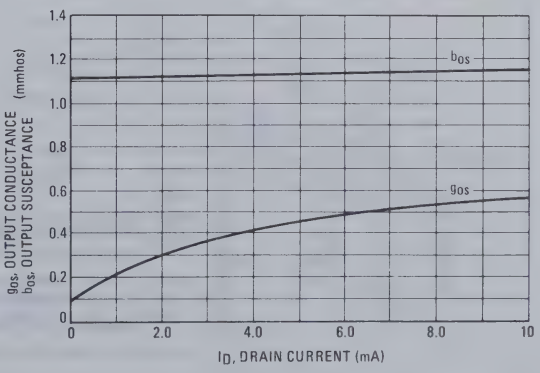


FIGURE 9 – POWER GAIN AND NOISE FIGURE versus DRAIN CURRENT

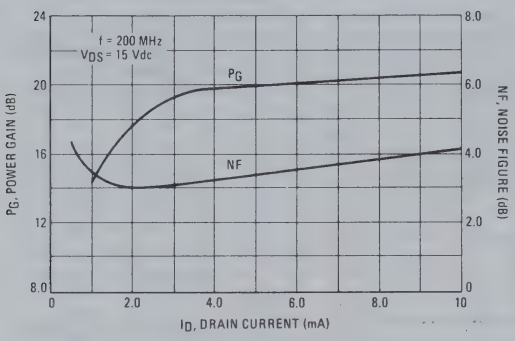


FIGURE 10 – POWER GAIN AND NOISE FIGURE versus DRAIN VOLTAGE

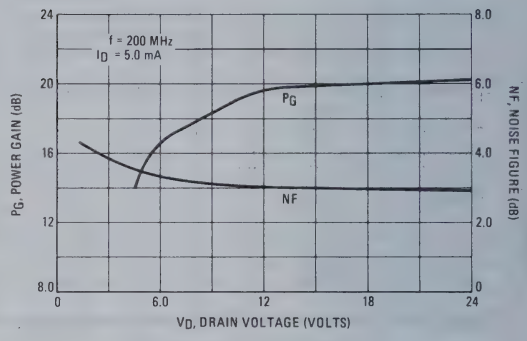


FIGURE 11 – THIRD ORDER INTERMODULATION DISTORTION

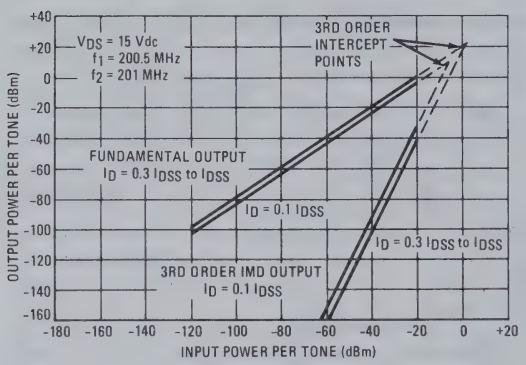
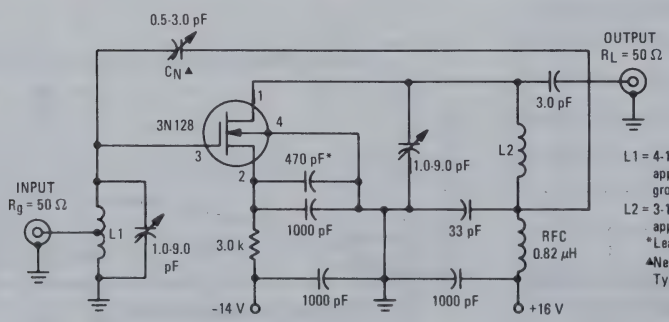


Figure 11 shows the typical third order intermodulation distortion (IMD) performance of the 3N128 at 200 MHz.

Both fundamental output and third order IMD output characteristics are plotted. The curves have been extrapolated to show the third order intermodulation output intercept point.

Performance for drain currents from I_{DSS} to 0.1 I_{DSS}, is given. The power gain and noise figure test amplifier shown in Figure 12 was used to generate the IMD data.

FIGURE 12 – POWER GAIN, NOISE FIGURE AND INTERMODULATION DISTORTION TEST CIRCUIT



L1 = 4-1/2 turns #20 AWG wire, 3/16" diameter, approximately 1/2" long, tapped 1 turn from ground end.

L2 = 3-1/2 turns #20 AWG wire, 3/8" diameter, approximately 1/2" long

*Leadless-type disc capacitor

▲Neutralization fixed for a Transistor having a Typical value of C_{rss} (0.13 pF)

3N140 (SILICON)

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTOR

Depletion mode (Type B) dual-gate transistor designed for VHF amplifier and mixer applications.

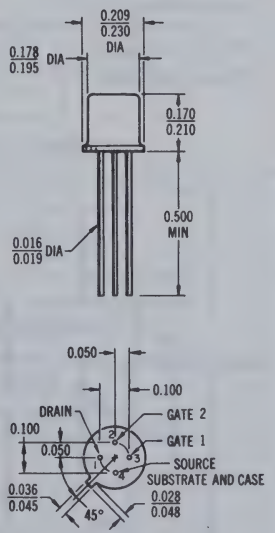
- Silicon-Nitride Passivation for Excellent Long Term Stability
- High Common-Source Power Gain — G_{ps} = 16 dB (Min) @ f = 200 MHz
- Low Reverse Transfer Capacitance — C_{rss} = 0.02 pF (Typ) @ V_{DS} = 13 Vdc

N-CHANNEL
DUAL-GATE MOS FIELD-EFFECT TRANSISTOR
Type B



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	0 to +20	Vdc
Drain-Gate 1 Voltage	V_{DG1}	20	Vdc
Drain-Gate 2 Voltage	V_{DG2}	20	Vdc
Reverse Gate 1-Source Voltage	$V_{GS1(r)}$	-8.0	Vdc
Reverse Gate 2-Source Voltage	$V_{GS2(r)}$	-8.0 to 0.4 V_{DS}	Vdc
Forward Gate 1-Source Voltage	$V_{GS1(f)}$	+1.0	Vdc
Forward Gate 2-Source Voltage	$V_{GS2(f)}$	0.4 V_{DS}	Vdc
Drain Current	I_D	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C



TO-72
CASE 20 (9)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

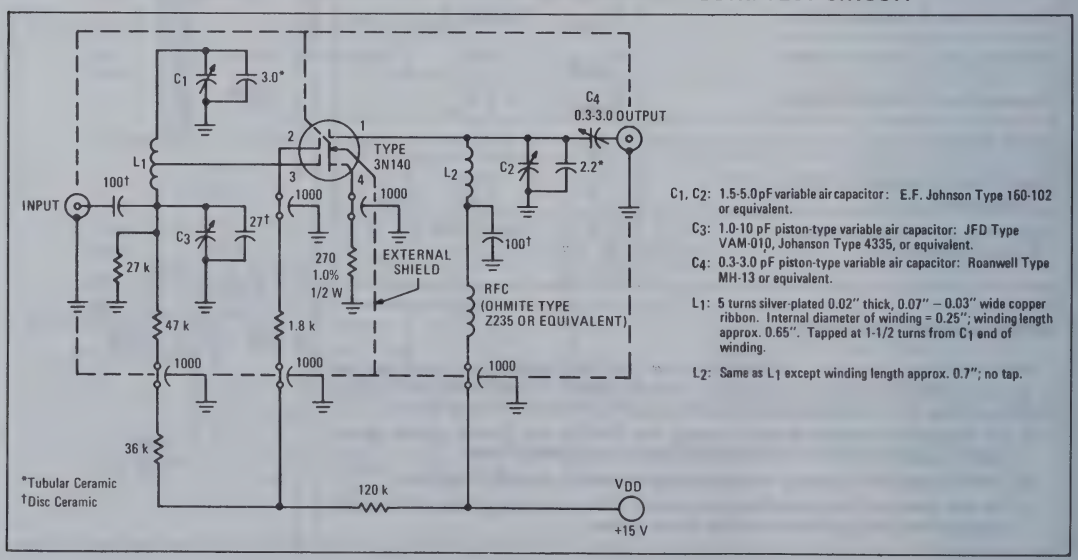
1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate 1-Source Cutoff Voltage (V_{DS} = +16 Vdc, I_D = 200 μAdc, V_{G2S} = +4.0 Vdc)	$V_{G1S(off)}$	-0.5	-4.0	Vdc
Gate 2-Source Cutoff Voltage (V_{DS} = +16 Vdc, I_D = 200 μAdc, V_{G1S} = 0)	$V_{G2S(off)}$	-0.5	-4.0	Vdc
Gate 1-Reverse Current (V_{G1S} = 20 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	-	1.0	nAdc
(V_{G1S} = 20 Vdc, V_{DS} = 0, V_{G2S} = 0, T_A = 125°C)		-	0.2	μAdc
Gate 2-Reverse Current (V_{G2S} = 20 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	-	1.0	nAdc
(V_{G2S} = 20 Vdc, V_{DS} = 0, V_{G1S} = 0, T_A = 125°C)		-	0.2	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DD} = +14 Vdc, V_{G1S} = 0, V_{G2S} = +14 Vdc)	I_{DSS}	5.0	30	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transconductance (V_{DD} = +14 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 kHz)	$Re(y_{fs})$**	6000	18,000	μmhos
Input Capacitance (V_{DS} = +13 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 MHz)	C_{iss}	3.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = +13 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 MHz)	C_{rss}*	0.01	0.03	pF
Common-Source Noise Figure (See Figure 1) (V_{DD} = +15 Vdc, R_S = 275 Ohms, R_G = 50 Ohms, f = 200 MHz)	NF	-	4.5	dB
Power Gain (See Figure 1) (f = 200 MHz)	G_{ps}	16	22	dB
Bandwidth (See Figure 1) (f = 200 MHz)	BW	9.5	14.5	MHz

*Drain-to-Gate 1
**Gate 1-to-Drain

FIGURE 1 – 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C_1, C_2: 1.5-5.0 pF variable air capacitor: E.F. Johnson Type 160-102 or equivalent.

C_3: 1.0-10 pF piston-type variable air capacitor: JFD Type VAM-010, Johanson Type 4335, or equivalent.

C_4: 0.3-3.0 pF piston-type variable air capacitor: Roanwell Type MH-13 or equivalent.

L_1: 5 turns silver-plated 0.02" thick, 0.07" – 0.03" wide copper ribbon. Internal diameter of winding = 0.25"; winding length approx. 0.65". Tapped at 1-1/2 turns from C_1 end of winding.

L_2: Same as L_1 except winding length approx. 0.7"; no tap.

3N155,A (SILICON)
3N156,A



PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

CASE 20 (2)
(TO-72)

P-channel silicon nitride passivated MOS field-effect enhancement mode transistors designed for chopper and switching application.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	35	Vdc
Drain-Gate Voltage	V_{DG}	35	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = -10 μAdc, V_G = V_S = 0)		$V_{(BR)DSS}$	35	-	-	Vdc
Gate Reverse Current		I_{GSS}				pAdc
(V_{GS} = +50 Vdc, V_{DS} = 0)			-	-	1000	
(V_{GS} = +25 Vdc, V_{DS} = 0)			-	-	10	
Zero-Gate Voltage Drain Current		I_{DSS}				nAdc
(V_{DS} = -10 Vdc, V_{GS} = 0)	3N155, 3N156		-	-	1.0	
	3N155A, 3N156A		-	-	0.25	
(V_{DS} = -10 Vdc, V_{GS} = 0, T_A = 125°C)	3N155, 3N156		-	-	1000	
	3N155A, 3N156A		-	-	250	
Resistance Drain Source (I_D = 0, V_{GS} = 0)		$R_{DS(off)}$	$1 \times 10^{+10}$	-	-	Ohms
Resistance Gate Source Input (V_{GS} = -25 Vdc)		R_{GS}	-	$1 \times 10^{+16}$	-	Ohms
ON CHARACTERISTICS						
Gate Source Threshold Voltage (V_{DS} = -10 Vdc, I_D = -10 μAdc)	3N155, 3N155A	$V_{GS(TH)}$	1.5	-	3.2	Vdc
	3N156, 3N156A		3.0	-	5.0	
Drain Source "ON" Voltage (I_D = -2.0 mAdc, V_{GS} = -10 Vdc)		$V_{DS(on)}$	-	-	-1.0	Vdc
Gate Forward Leakage Current		$I_{G(f)}$				pAdc
(V_{GS} = -50 Vdc, V_{DS} = 0)			-	-	1000	
(V_{GS} = -25 Vdc, V_{DS} = 0)			-	-	10	
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc)		$I_{D(on)}$	5.0	-	-	mAdc
Static Drain-Source "ON" Resistance		$r_{DS(on)}$				Ohms
(I_D = 0 mAdc, V_{GS} = -10 Vdc)	3N155, 3N156		-	-	600	
	3N155A, 3N156A		-	-	300	
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source Resistance		$r_{ds(on)}$				Ohms
(V_{GS} = -10 Vdc, I_D = 0, f = 1.0 kHz)	3N155, 3N156		-	-	600	
	3N155A, 3N156A		-	-	300	
(V_{GS} = -15 Vdc, I_D = 0, f = 1.0 kHz)	3N155, 3N156		-	-	500	
	3N155A, 3N156A		-	-	250	
Forward Transfer Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc, f = 140 kHz)		C_{iss}	-	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	-	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = -10 Vdc, f = 140 kHz)		$C_{d(sub)}$	4.0	-	-	pF
SWITCHING CHARACTERISTICS						
Turn-On Delay	(V_{DD} = -10 Vdc, $I_{D(on)}$ = -2.0 mAdc, $V_{GS(on)}$ = -10 Vdc, $V_{GS(off)}$ = 0) Test Circuit given in Figure 1	t_d	-	-	45	μs
Rise Time		t_r	-	-	65	ns
Turn-Off Delay		t_s	-	-	60	ns
Fall Time		t_f	-	-	100	ns

FIGURE 1 – GATE VOLTAGE EFFECTS

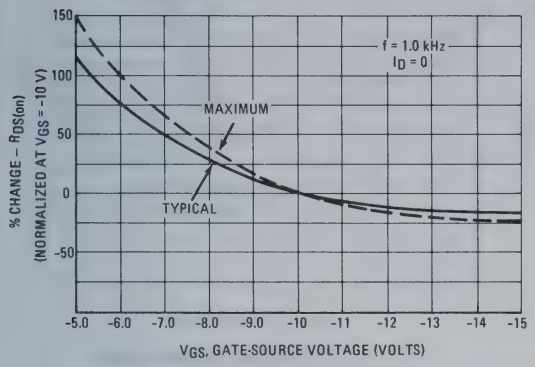


FIGURE 2 – TEMPERATURE EFFECTS

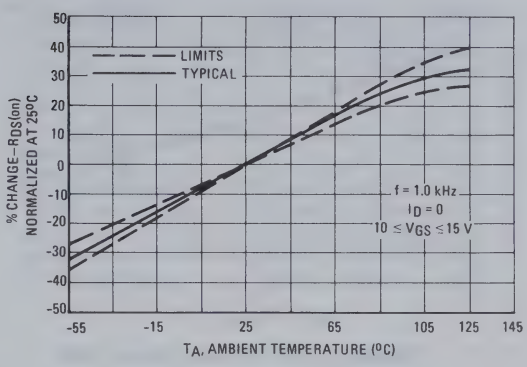


FIGURE 3 – DRAIN CURRENT versus TEMPERATURE

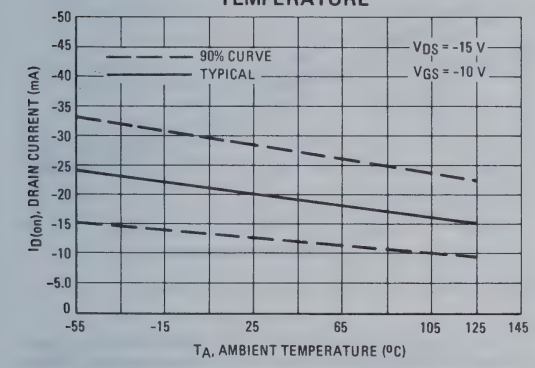


FIGURE 4 – "ON" DRAIN-SOURCE VOLTAGE

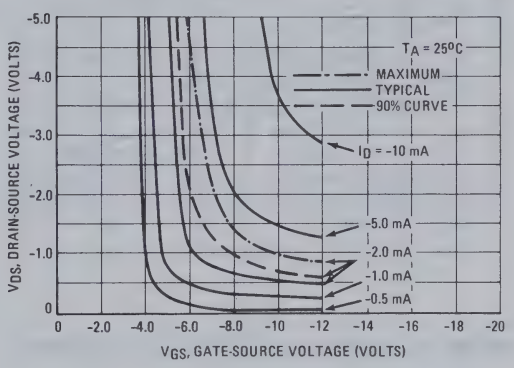


FIGURE 5 – LEAKAGE CURRENTS

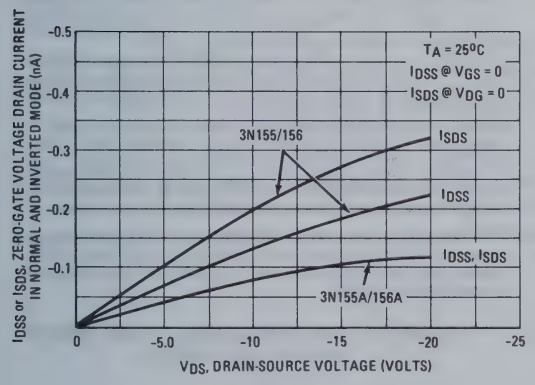
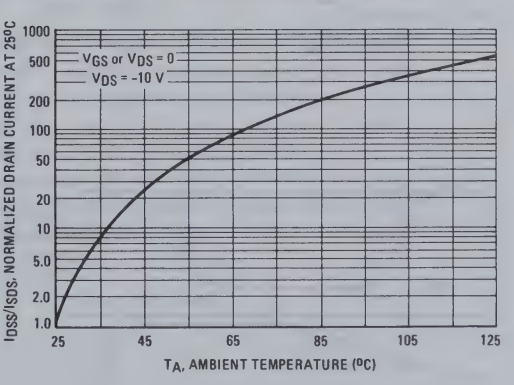


FIGURE 6 – LEAKAGE CURRENT versus TEMPERATURE



SWITCHING CHARACTERISTICS

$T_A = 25^oC$

FIGURE 7 – TURN-ON DELAY TIME

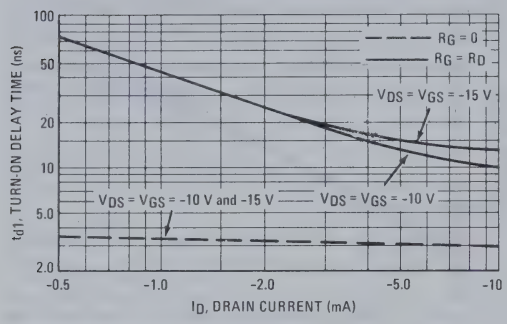


FIGURE 8 – RISE TIME

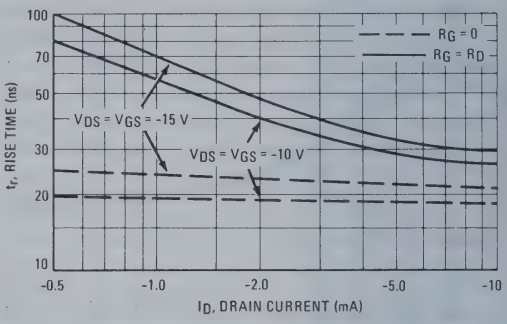


FIGURE 9 – TURN-OFF DELAY TIME

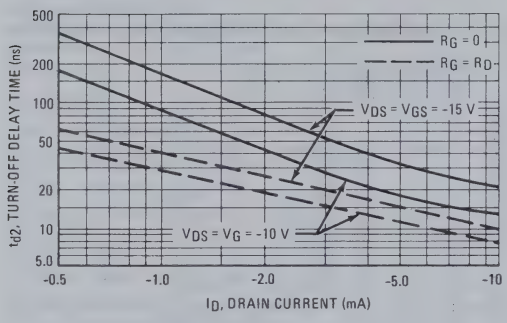


FIGURE 10 – FALL TIME

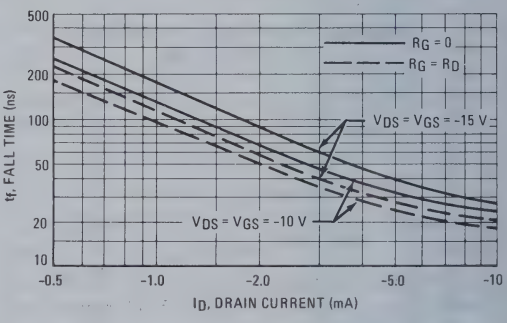
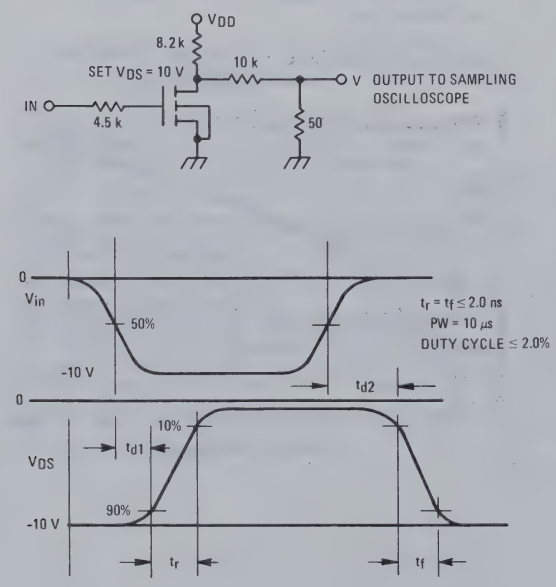


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

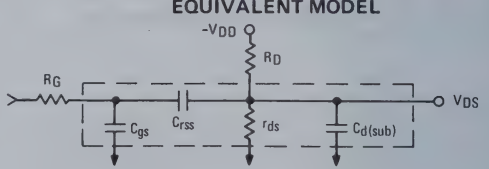
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with d_s. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_G = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_G = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_G = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



3N157,A (SILICON)
3N158,A



PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

CASE 20 (2)
(TO-72)

P-channel silicon nitride passivated MOS field-effect enhancement mode transistors designed for chopper and switching application.

MAXIMUM RATINGS

Rating	Symbol	3N157 3N158	3N157A 3N158A	Unit
Drain-Source Voltage	V_{DS}	35	50	Vdc
Drain-Gate Voltage	V_{DG}	35	50	Vdc
Gate-Source Voltage	V_{GS}	50		Vdc
Drain Current	I_D	30		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7		mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = -10 μAdc, V_G = V_S = 0)	3N157, 3N158 3N157A, 3N158A	$V_{(BR)DSS}$	35 50	- -	- -	Vdc
Gate Reverse Current (V_{GS} = +25 Vdc, V_{DS} = 0)		I_{GSS}	-	-	10	pAdc
Zero-Gate Voltage Drain Current (V_{DS} = -15 Vdc, V_{GS} = 0)	3N157, 3N158 3N157A, 3N158A	I_{DSS}	- -	- -	1.0 0.25	nAdc
(V_{DS} = -35 Vdc, V_{GS} = 0)	3N157, 3N158		-	-	10	μAdc
(V_{DS} = -50 Vdc, V_{GS} = 0)	3N157A, 3N158A		-	-	10	
Input Resistance (V_{GS} = -25 Vdc)		R_{GS}	-	$1 \times 10^{+12}$	-	Ohms
ON CHARACTERISTICS						
Gate-Source Threshold Voltage (V_{DS} = -15 Vdc, I_D = -10 μAdc)	3N157, 3N157A 3N158, 3N158A	$V_{GS(TH)}$	1.5 3.0	- -	3.2 5.0	Vdc
Gate-Source Voltage (V_{DS} = -15 Vdc, I_D = -0.5 mAdc)	3N157, 3N157A 3N158, 3N158A	V_{GS}	1.5 3.0	- -	5.5 7.0	Vdc
Gate Forward Current (V_{GS} = -25 Vdc, V_{DS} = 0)		$I_{G(f)}$	-	-	10	pAdc
(V_{GS} = -25 Vdc, V_{DS} = 0, T_A = +55°C)			-	-	10	nAdc
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc)		$I_{D(on)}$	5.0	-	-	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
(V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)			1800	-	-	
Output Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{os} \rvert$	-	-	60	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{iss}	-	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	-	1.3	pF
Drain-Substrate Capacitance ($V_{D(sub)}$ = -10 Vdc, f = 140 kHz)		$C_{d(sub)}$	-	-	4.0	pF
Noise Voltage (R_S = 0, BW = 1.0 Hz, V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 100 Hz)		e_n	-	300	-	$NV/\sqrt{Hz}$
(R_S = 0, BW = 1.0 Hz, V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)			-	120	500	

FIGURE 1 – FORWARD TRANSCONDUCTANCE

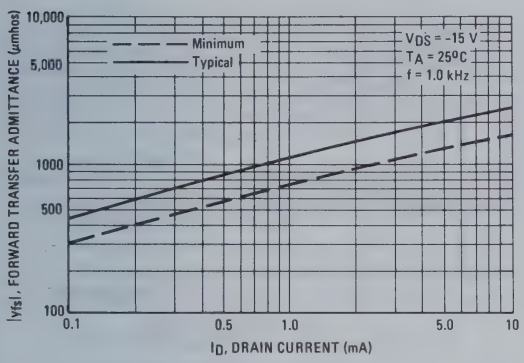


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

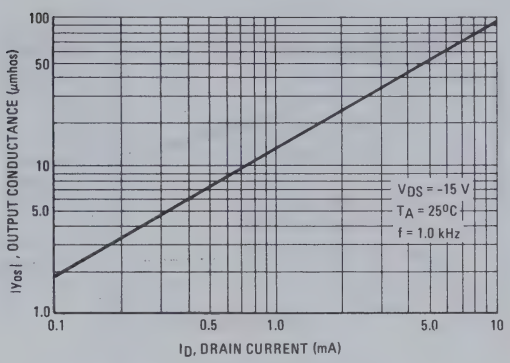


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus TEMPERATURE

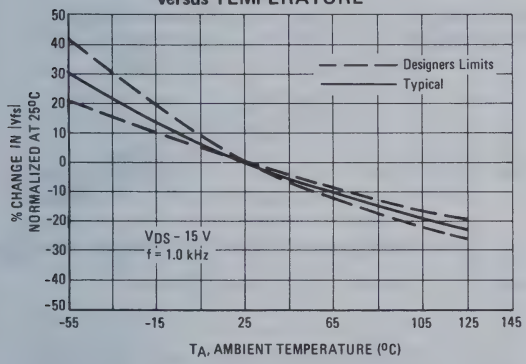


FIGURE 4 – BIAS CURVE

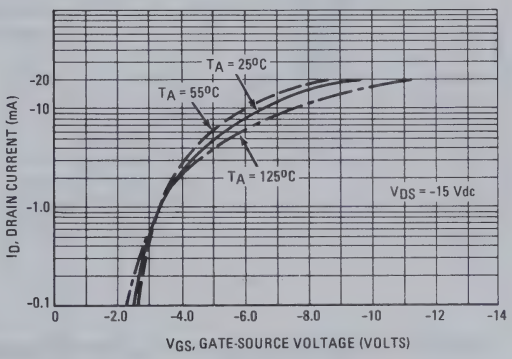


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

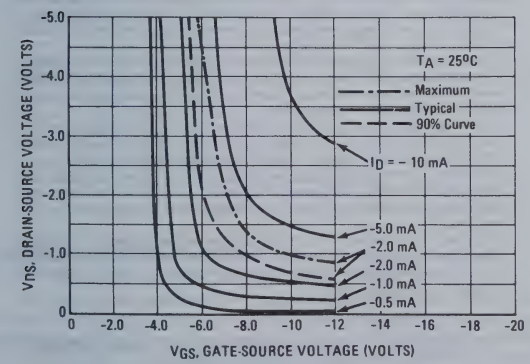
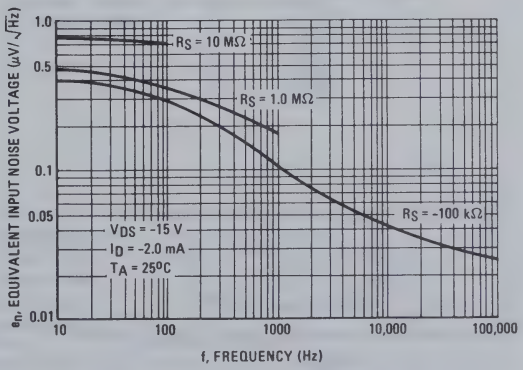


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 7 – TURN-ON DELAY TIME

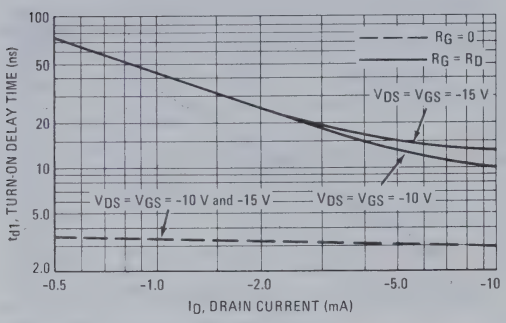


FIGURE 8 – RISE TIME

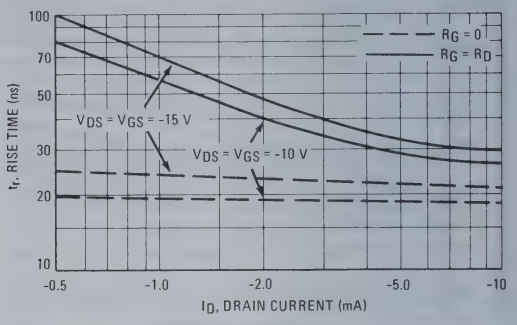


FIGURE 9 – TURN-OFF DELAY TIME

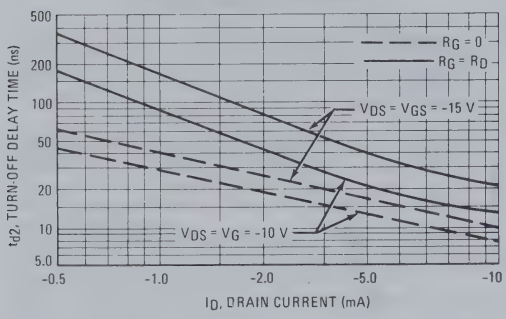


FIGURE 10 – FALL TIME

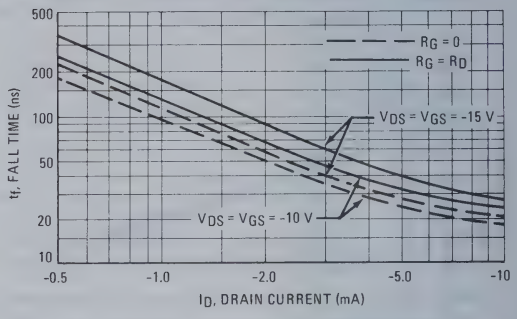
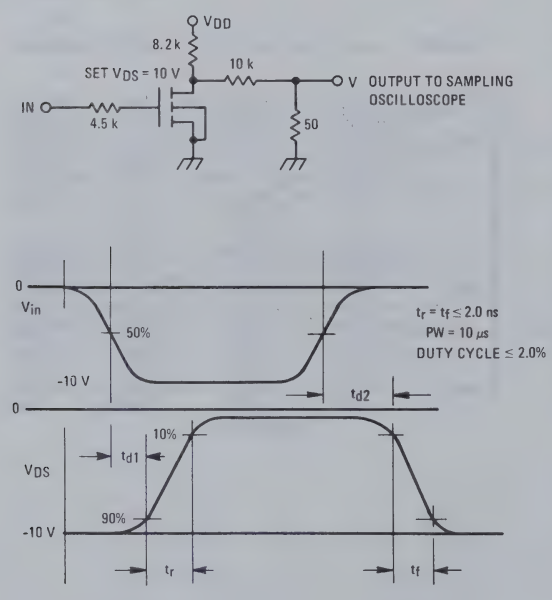


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 11 At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance (C_{gs} = C_{iss} – C_{rss}) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

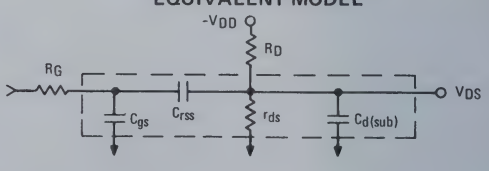
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to V_{GS} – $V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where R_G = 0 and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with R_G = R_D simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with R_G = 0 simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



3N169 (SILICON)
3N170
3N171

SILICON N-CHANNEL
MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode transistors designed for low-power switching applications.

- Low Switching Voltages – $V_{GS(th)} \leqslant 3.0$ Vdc
- Fast Switching Times – $t_r \leqslant 10$ ns
- Low Drain-Source Resistance $r_{ds(on)}$ = 200 Ohms (Max)
- Low Reverse Transfer Capacitance C_{rss} = 1.3 pF (Max)
- Manufactured Using the New Silicon Nitride Process Resulting in a Stable $V_{GS(th)}$ and Gate Oxide Breakdown Protection to Typical Transients of ±150 Volts Peak

MOS FIELD-EFFECT TRANSISTORS

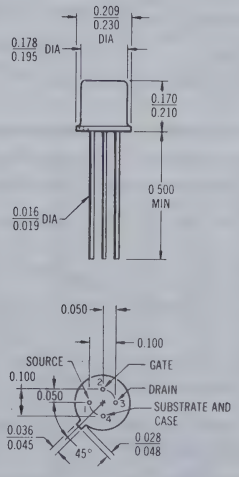
N-CHANNEL



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
*Drain-Source Voltage	V_{DS}	25	Vdc
*Drain-Gate Voltage	V_{DG}	±35	Vdc
*Gate-Source Voltage	V_{GS}	±35	Vdc
*Drain Current	I_D	30	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
*Power Dissipation @ T_C = 25°C *Derate above 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	175	°C
*Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (2)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		–	$V_{(BR)DSS}$	25	–	Vdc
*Gate Leakage Current		–	I_{GSS}			pAdc
(V_{GS} = -35 Vdc, V_{DS} = 0)				–	10	
(V_{GS} = -35 Vdc, V_{DS} = 0, T_A = 125°C)				–	100	
*Zero-Gate-Voltage Drain Current		–	I_{DSS}			nAdc
(V_{DS} = 10 Vdc, V_{GS} = 0)				–	10	
(V_{DS} = 10 Vdc, V_{GS} = 0, T_A = 125°C)				–	1.0	μAdc
***ON CHARACTERISTICS**						
Gate-Source Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	3N169	–	$V_{GS(th)}$	0.5	1.5	Vdc
	3N170			1.0	2.0	
	3N171			1.5	3.0	
"ON" Drain Current (V_{GS} = 10 Vdc, V_{DS} = 10 Vdc)		3	$I_{D(on)}$	10	–	mAdc
Drain-Source "ON" Voltage (I_D = 10 mAdc, V_{GS} = 10 Vdc)		–	$V_{DS(on)}$	–	2.0	Vdc
SMALL SIGNAL CHARACTERISTICS						
*Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)		4	$r_{ds(on)}$	–	200	Ohms
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)		1	$\|Y_{fs}\|$	1000	–	μmhos
*Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		2	C_{rss}	–	1.3	pF
*Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		2	C_{iss}	–	5.0	pF
*Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)		–	$C_{d(sub)}$	–	5.0	pF
***SWITCHING CHARACTERISTICS**						
Turn-On Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, R_G' = 50 Ohms)	6,10	$t_{d(on)}$	–	3.0	ns
Rise Time		7,10	t_r	–	10	ns
Turn-Off Delay Time		8,10	$t_{d(off)}$	–	3.0	ns
Fall Time		9,10	t_f	–	15	ns

*Indicates JEDEC Registered Data.

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

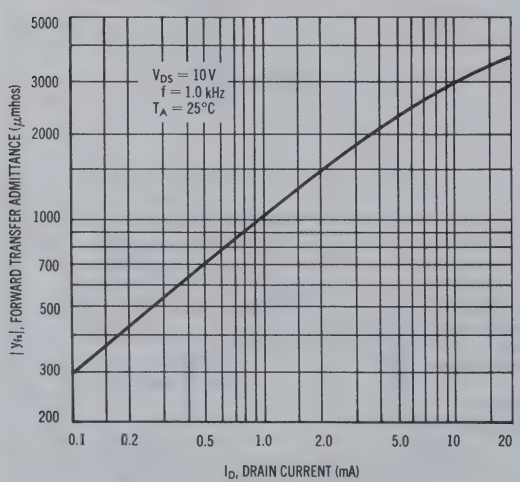


FIGURE 2 – CAPACITANCE

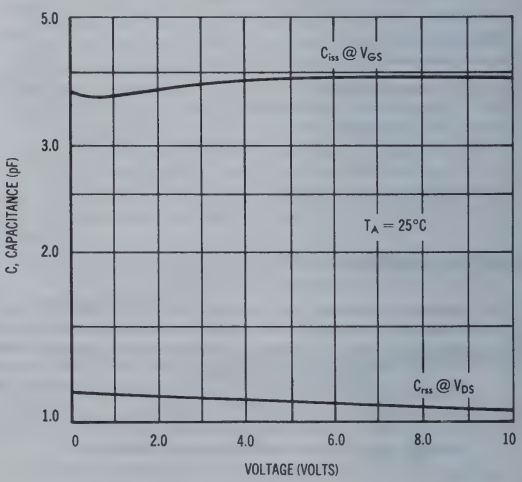


FIGURE 3 – TRANSFER CHARACTERISTICS

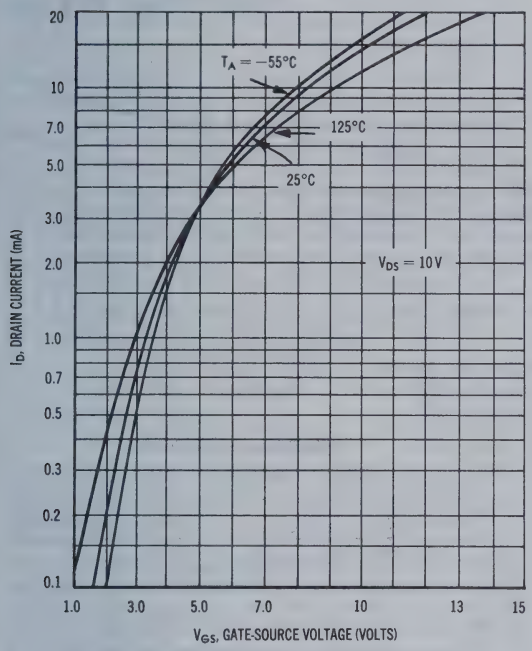


FIGURE 4 – DRAIN-SOURCE "ON" RESISTANCE

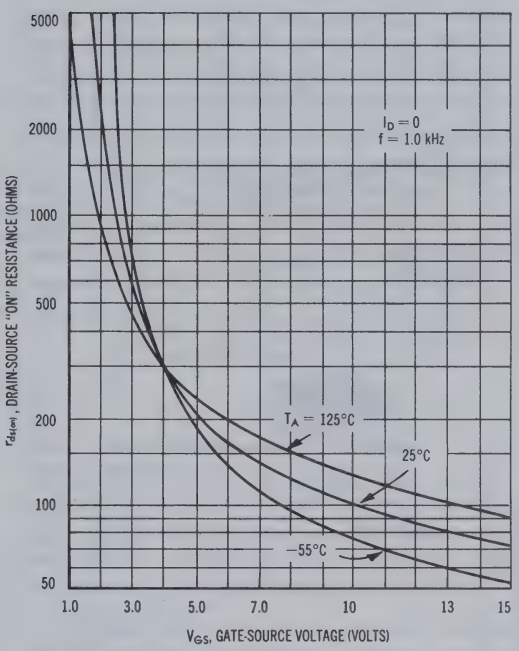
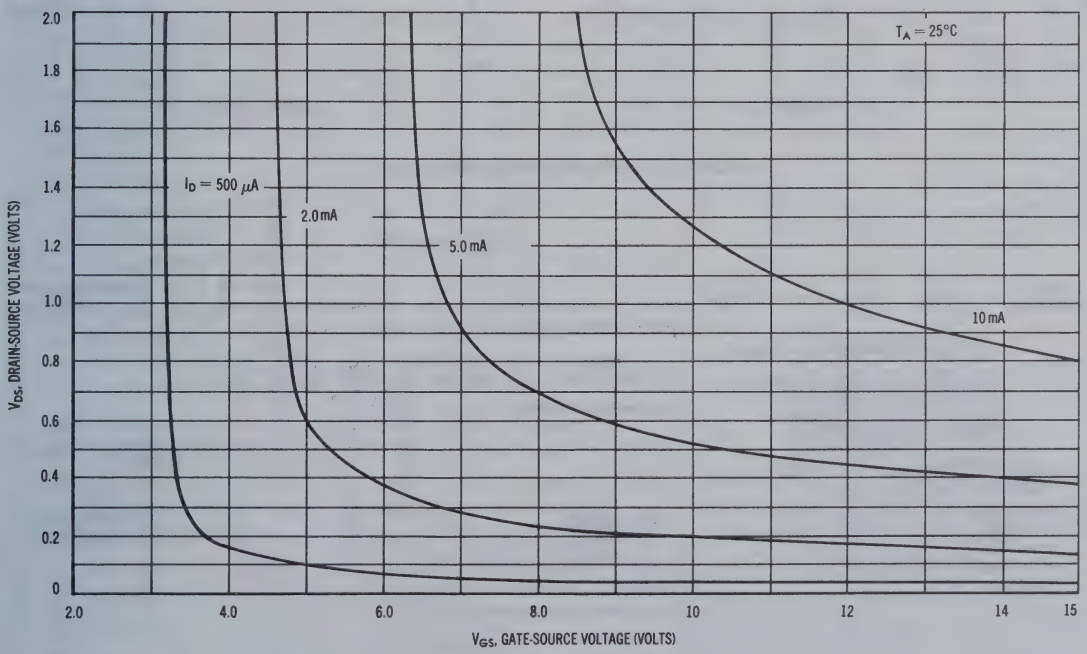


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE



TYPICAL SWITCHING CHARACTERISTICS
$T_A = 25^oC$

FIGURE 6 – TURN-ON DELAY TIME

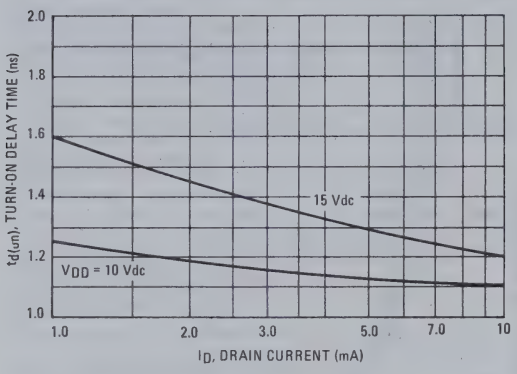


FIGURE 7 – RISE TIME

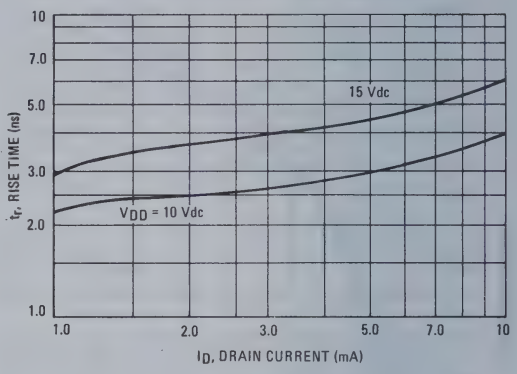


FIGURE 8 – TURN-OFF DELAY TIME

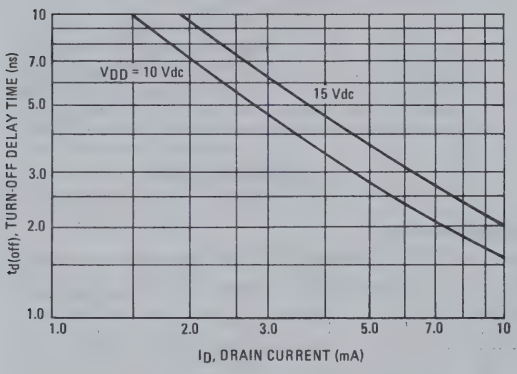


FIGURE 9 – FALL TIME

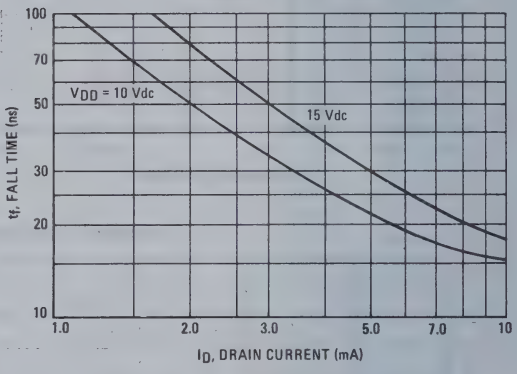
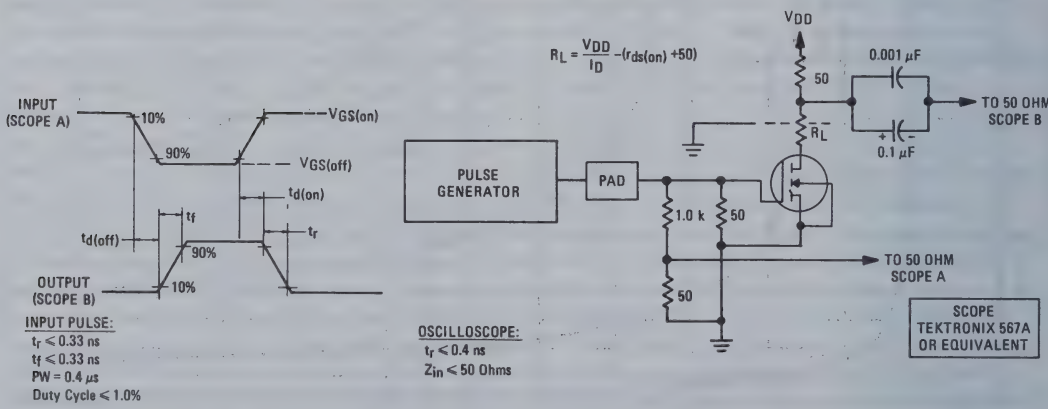


FIGURE 10 – SWITCHING TIME TEST CIRCUIT



4N25 (MOC1001)

4N26 (MOC1000)

4N27 (MOC1002)

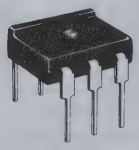
4N28 (MOC1003)

NPN PHOTOTRANSISTOR AND PN INFRARED EMITTING DIODE

. . . Gallium Arsenide LED optically coupled to a Silicon Photo Transistor designed for applications requiring electrical isolation, high-current transfer ratios, small package size and low cost; such as interfacing and coupling systems, phase and feedback controls, solid-state relays and general-purpose switching circuits.

- High Isolation Voltage –
  V_{ISO} = 2500 V (Min) – 4N25
  1500 V (Min) – 4N26, 4N27
  500 V (Min) – 4N28
- High Collector Output Current @ I_F = 10 mA –
  I_C = 5.0 mA (Typ) – 4N25, 4N26
  3.0 mA (Typ) – 4N27, 4N28
- Economical, Compact, Dual-In-Line Package
- Excellent Frequency Response – 300 kHz (Typ)
- Fast Switching Times @ I_C = 10 mA
  t_{on} = 0.87 μs (Typ) – 4N25, 4N26
  2.1 μs (Typ) – 4N27, 4N28
  t_{off} = 11 μs (Typ) – 4N25, 4N26
  5.0 μs (Typ) – 4N27, 4N28

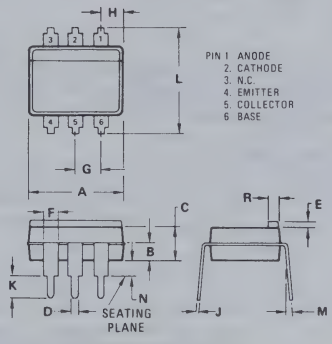
INFRARED LIGHT EMITTING DIODE PHOTOTRANSISTOR COUPLED PAIR



***MAXIMUM RATINGS** (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED-EMITTING DIODE MAXIMUM RATINGS			
Reverse Voltage	V_R	3.0	Volts
Forward Current – Continuous	I_F	80	mA
Forward Current – Peak (Pulse Width = 300 μs, 2.0% Duty Cycle)	I_F	3.0	Amp
Total Device Dissipation @ T_A = 25°C Negligible Power in Transistor Derate above 25°C	P_D	150 2.0	mW mW/°C
PHOTOTRANSISTOR MAXIMUM RATINGS			
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CBO}	70	Volts
Total Device Dissipation @ T_A = 25°C Negligible Power in Diode Derate above 25°C	P_D	150 2.0	mW mW/°C
TOTAL DEVICE RATINGS			
Total Device Dissipation @ T_A = 25°C Equal Power Dissipation in Each Element Derate above 25°C	P_D	250 3.3	mW mW/°C
Junction Temperature Range	T_J	-55 to +100	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C
Soldering Temperature (10 s)		260	°C

* Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.38	8.89	0.330	0.350
B	1.40	1.65	0.055	0.065
C	2.92	3.18	0.115	0.125
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	1.14	1.40	0.045	0.055
G	2.54 BSC		0.100 BSC	
H	1.57	1.83	0.062	0.072
J	0.23	0.28	0.009	0.011
K	2.54	3.30	0.100	0.130
L	7.37	7.87	0.290	0.310
M	–	5°	–	5°
N	–	1.27	–	0.050
R	1.52	1.78	0.060	0.070

CASE 673-03

FIGURE 1 – MAXIMUM POWER DISSIPATION

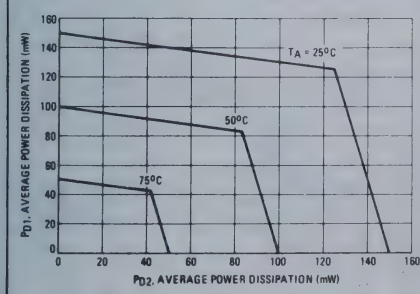


Figure 1 is based upon using limit values in the equation:

$T_{J1} - T_A = R_{\theta JA} (P_{D1} + K_\theta P_{D2})$

where:

T_{J1} Junction Temperature (100°C)

T_A Ambient Temperature

$R_{\theta JA}$ Junction to Ambient Thermal Resistance (500°C/W)

P_{D1} Power Dissipation in One Chip

P_{D2} Power Dissipation in Other Chip

K_θ Thermal Coupling Coefficient (20%)

Example:

With P_{D1} = 90 mW in the LED @ T_A = 50°C, the transistor P_D (P_{D2}) must be less than 50 mW.

LED CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 M ohms)	I_R	–	0.05	100	μA
*Forward Voltage (I_F = 50 mA)	V_F	–	1.2	1.5	Volts
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	–	150	–	pF

PHOTOTRANSISTOR CHARACTERISTICS (T_A = 25°C and I_F = 0 unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Collector-Emitter Dark Current (V_{CE} = 10 V, Base Open)	4N25, 4N26, 4N27 4N28	I_{CEO}	– –	3.5 –	50 100	nA
*Collector-Base Dark Current (V_{CB} = 10 V, Emitter Open)		I_{CBO}	–	–	20	nA
*Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)		BV_{CBO}	70	–	–	Volts
*Collector-Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)		BV_{CEO}	30	–	–	Volts
*Emitter-Collector Breakdown Voltage (I_E = 100 μA, I_B = 0)		BV_{ECO}	7.0	–	–	Volts
DC Current Gain (V_{CE} = 5.0 V I_C = 500 μA)		h_{FE}	–	250	–	–

COUPLED CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Collector Output Current (1) (V_{CE} = 10 V, I_F = 10 mA, I_B = 0)	4N25,4N26 4N27,4N28	I_C	2.0 1.0	5.0 3.0	– –	mA
*Isolation Voltage (2)	4N25 4N26,4N27 4N28	V_{ISO}	2500 1500 500	– – –	– – –	Volts
Isolation Resistance (2) (V = 500 V)		–	–	10^{11}	–	Ohms
*Collector-Emitter Saturation (I_C = 2.0 mA, I_F = 50 mA)		$V_{CE(sat)}$		0.2	0.5	Volts
Isolation Capacitance (2) (V = 0, f = 1.0 MHz)		–	–	1.3	–	pF
Bandwidth (3) (I_C = 2.0 mA, R_L = 100 ohms, Figure 11)		–		300	–	kHz

SWITCHING CHARACTERISTICS

Delay Time	(I_C = 10 mA, V_{CC} = 10 V)	4N25,4N26 4N27,4N28	t_d	– –	0.07 0.10	– –	μs
Rise Time	Figures 6 and 8	4N25,4N26 4N27,4N28	t_r	– –	0.8 2.0	– –	μs
Storage Time	(I_C = 10 mA, V_{CC} = 10 V)	4N25,4N26 4N27,4N28	t_s	– –	4.0 2.0	– –	μs
Fall Time	Figures 7 and 8	4N25,4N26 4N27,4N28	t_f	– –	7.0 3.0	– –	μs

*Indicates JEDEC Registered Data. (1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≤ 2.0%
(2) For this test LED pins 1 and 2 are common and Photo Transistor pins 4, 5 and 6 are common.
(3) I_F adjusted to yield I_C = 2.0 mA and i_c = 2.0 mA p-p at 10 kHz.

DC CURRENT TRANSFER CHARACTERISTICS

FIGURE 2 – 4N25, 4N26

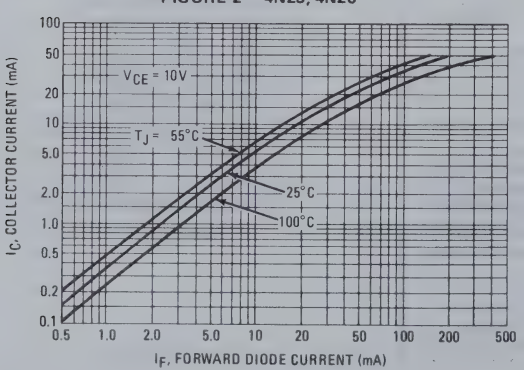
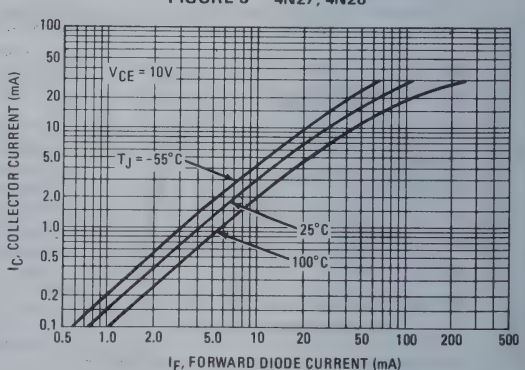


FIGURE 3 – 4N27, 4N28



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – DIODE FORWARD CHARACTERISTICS

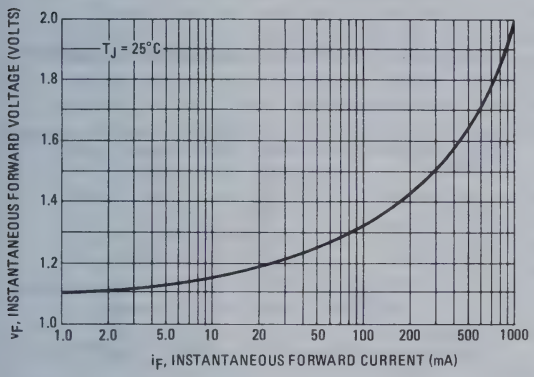


FIGURE 5 – COLLECTOR SATURATION VOLTAGE

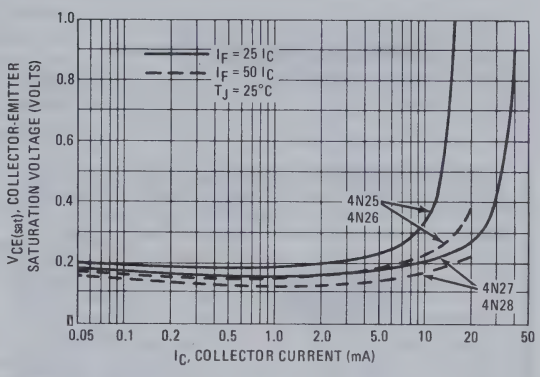


FIGURE 6 – TURN-ON TIME

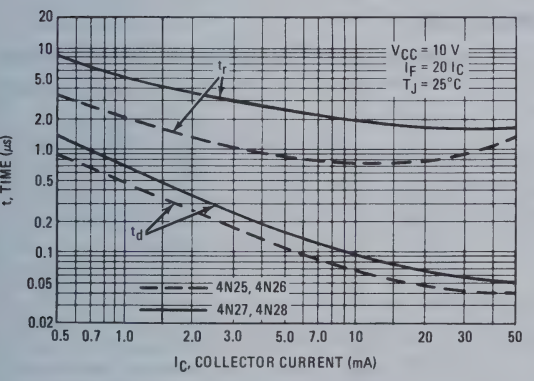


FIGURE 7 – TURN-OFF TIME

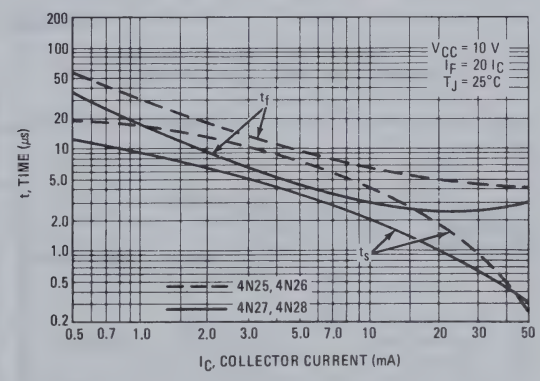


FIGURE 8 – SATURATED SWITCHING TIME TEST CIRCUIT

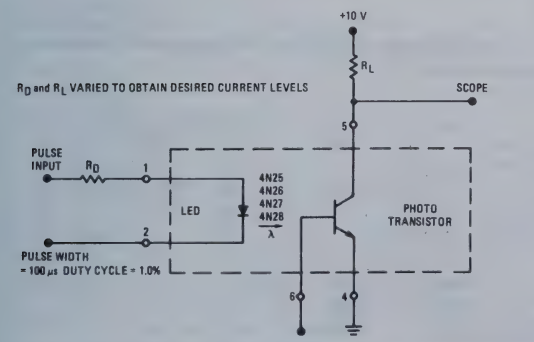


FIGURE 9 – DARK CURRENT versus AMBIENT TEMPERATURE

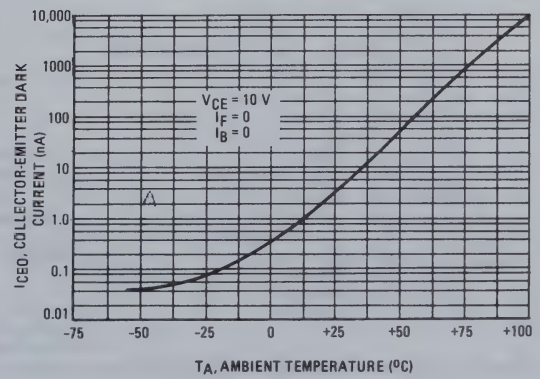


FIGURE 10 – FREQUENCY RESPONSE

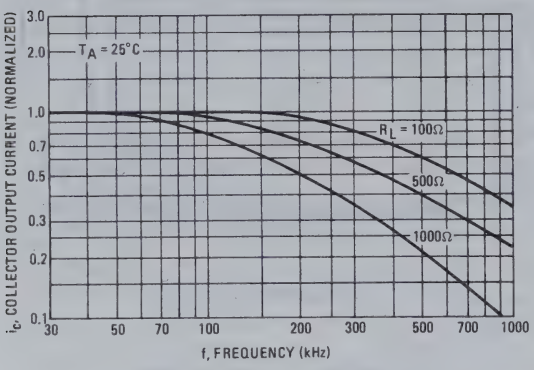
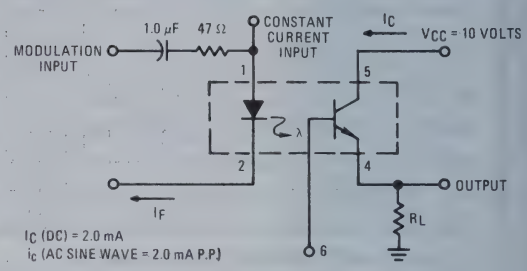


FIGURE 11 – FREQUENCY RESPONSE TEST CIRCUIT



TYPICAL APPLICATIONS

FIGURE 12 – ISOLATED MTTL TO MOS (P-CHANNEL) LEVEL TRANSLATOR

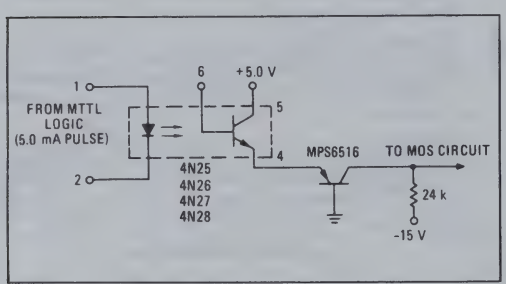


FIGURE 13 – COMPUTER/PERIPHERAL INTERCONNECT

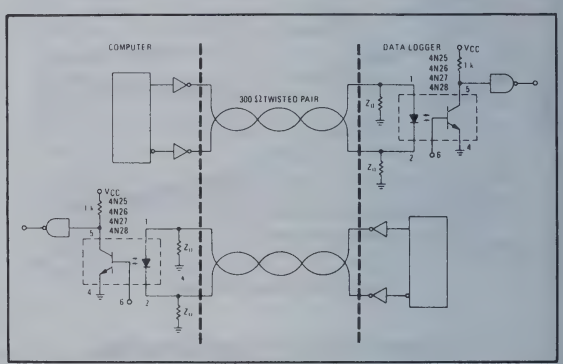


FIGURE 14 – POWER AMPLIFIER

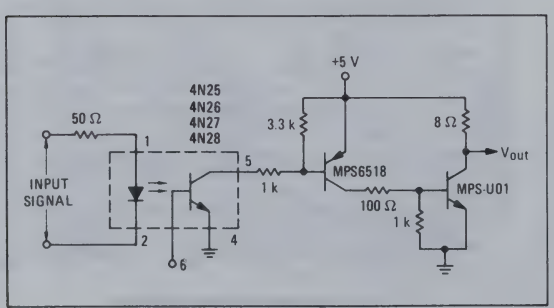
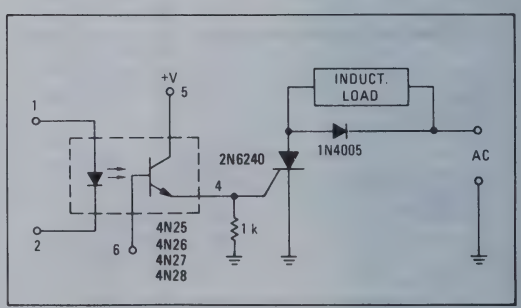


FIGURE 15 – INTERFACE BETWEEN LOGIC AND LOAD



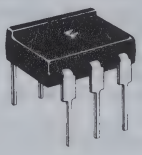
4N29, 4N30 (MOC1200)
4N31, 4N32, 4N33

NPN PHOTOTRANSISTOR AND PN INFRARED EMITTING DIODE

. . . Gallium Arsenide LED optically coupled to a Silicon Photo Darlington Transistor designed for applications requiring electrical isolation, high-current transfer ratios, small package size and low cost; such as interfacing and coupling systems, phase and feedback controls, solid-state relays and general-purpose switching circuits.

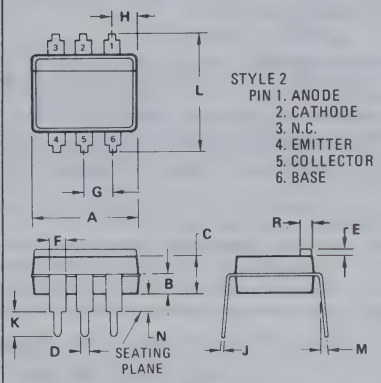
- High Isolation Voltage — V_{ISO} = 2500 V (Min) — 4N29,32
  1500 V (Min) — 4N30,31,33
- High Collector Output Current @ I_F = 10 mA —
  I_C = 50 mA (Min) — 4N32,33
  10 mA (Min) — 4N29,30
  5.0 mA (Min) — 4N31
- Economical, Compact, Dual-In-Line Package
- Excellent Frequency Response — 30 kHz (Typ)
- Fast Switching Times @ I_C = 50 mA
  t_{on} = 0.6 μs (Typ)
  t_{off} = 17 μs (Typ) — 4N29,30,31
  45 μs (Typ) — 4N32,33

INFRARED LIGHT EMITTING DIODE PHOTO DARLINGTON TRANSISTOR COUPLED PAIR



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED-EMITTING DIODE MAXIMUM RATINGS			
Reverse Voltage	V_R	3.0	Volts
Forward Current — Continuous	I_F	80	mA
Forward Current — Peak (Pulse Width = 300 μs, 2.0% Duty Cycle)	I_F	3.0	Amp
Total Power Dissipation @ T_A = 25°C Negligible Power in Transistor Derate above 25°C	P_D	150 2.0	mW mW/°C
PHOTOTRANSISTOR MAXIMUM RATINGS			
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	5.0	Volts
Collector-Base Voltage	V_{CBO}	30	Volts
Total Power Dissipation @ T_A = 25°C Negligible Power in Diode Derate above 25°C	P_D	150 2.0	mW mW/°C
TOTAL DEVICE RATINGS			
Total Device Dissipation @ T_A = 25°C Equal Power Dissipation in Each Element Derate above 25°C	P_D	250 3.3	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +100	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C
Soldering Temperature (10 s)	—	260	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.38	8.89	0.330	0.350
B	1.40	1.65	0.055	0.065
C	2.92	3.18	0.115	0.125
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	1.14	1.40	0.045	0.055
G	2.54 BSC		0.100 BSC	
H	1.57	1.83	0.062	0.072
J	0.23	0.28	0.009	0.011
K	2.54	3.30	0.100	0.130
L	7.37	7.87	0.290	0.310
M	—	5°	—	5°
N	—	1.27	—	0.050
R	1.52	1.78	0.060	0.070

CASE 673-03

FIGURE 1 — MAXIMUM POWER DISSIPATION

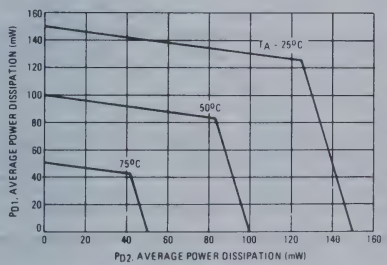


Figure 1 is based upon using limit values in the equation:

$T_{J1} - T_A = R_{\theta JA} (P_{D1} + K_\theta P_{D2})$

where:

- T_{J1} Junction Temperature (100°C)
- T_A Ambient Temperature
- $R_{\theta JA}$ Junction to Ambient Thermal Resistance (500°C/W)
- P_{D1} Power Dissipation in One Chip
- P_{D2} Power Dissipation in Other Chip
- K_θ Thermal Coupling Coefficient (20%)

Example:

With P_{D1} = 90 mW in the LED @ T_A = 50°C, the Darlington P_D (P_{D2}) must be less than 50 mW.

LED CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
*Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 M ohms)	I_R	–	0.05	100	μA
*Forward Voltage (I_F = 50 mA)	V_F	–	1.2	1.5	Volts
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	–	150	–	pF

PHOTOTRANSISTOR CHARACTERISTICS (T_A = 25°C and I_F = 0 unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
*Collector-Emitter Dark Current (V_{CE} = 10 V, Base Open)	I_{CEO}	–	–	100	nA
*Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	BV_{CBO}	30	–	–	Volts
*Collector-Emitter Breakdown Voltage (I_C = 100 μA, I_B = 0)	BV_{CEO}	30	–	–	Volts
*Emitter-Collector Breakdown Voltage (I_E = 100 μA, I_B = 0)	BV_{ECO}	5.0	–	–	Volts
DC Current Gain (V_{CE} = 5.0 V, I_C = 500 μA)	h_{FE}	–	5000	–	–

COUPLED CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
*Collector Output Current (1) (V_{CE} = 10 V, I_F = 10 mA, I_B = 0)	4N32, 4N33	I_C	50	–	–	mA
	4N29, 4N30		10	–	–	
	4N31		5.0	–	–	
*Isolation Voltage (2)	4N29, 4N32	V_{ISO}	2500	–	–	Volts
	4N30, 4N31, 4N33		1500	–	–	
Isolation Resistance (2) (V = 500 V)		–	–	10^{11}	–	Ohms
*Collector-Emitter Saturation Voltage (1) (I_C = 2.0 mA, I_F = 8.0 mA)	4N31	$V_{CE(sat)}$	–	–	1.2	Volts
	4N29, 4N30, 4N32, 4N33		–	–	1.0	
Isolation Capacitance (2) (V = 0, f = 1.0 MHz)		–	–	0.8	–	pF
Bandwidth (3) (I_C = 2.0 mA, R_L = 100 ohms, Figures 6 and 8)		–	–	30	–	kHz

SWITCHING CHARACTERISTICS (Figures 7 and 9), (4)

Turn-On Time (I_C = 50 mA, I_F = 200 mA, V_{CC} = 10 V)		t_{on}	–	0.6	5.0	μs
Turn-Off Time (I_C = 50 mA, I_F = 200 mA, V_{CC} = 10 V)	4N29,30,31	t_{off}	–	17	40	μs
	4N32,33		–	45	100	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

(2) For this test LED pins 1 and 2 are common and Photo Transistor pins 4,5 and 6 are common.

(3) I_F adjusted to yield I_C = 2.0 mA and i_c = 2.0 mA P-P at 10 kHz.

(4) t_d and t_r are inversely proportional to the amplitude of I_F; t_s and t_f are not significantly affected by I_F.

DC CURRENT TRANSFER CHARACTERISTICS

FIGURE 2 – 4N29, 4N30, 4N31

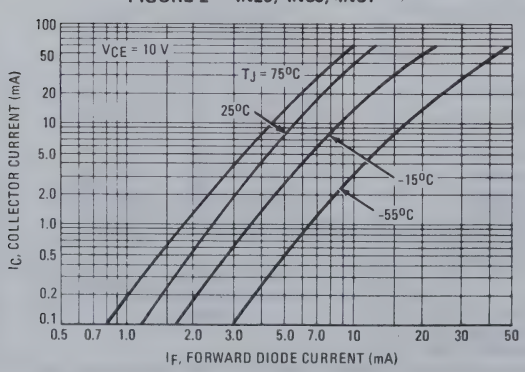
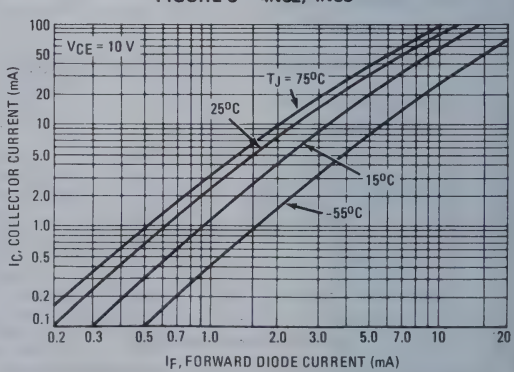


FIGURE 3 – 4N32, 4N33



TYPICAL ELECTRICAL CHARACTERISTICS

(Printed Circuit Board Mounting)

FIGURE 4 – DIODE FORWARD CHARACTERISTIC

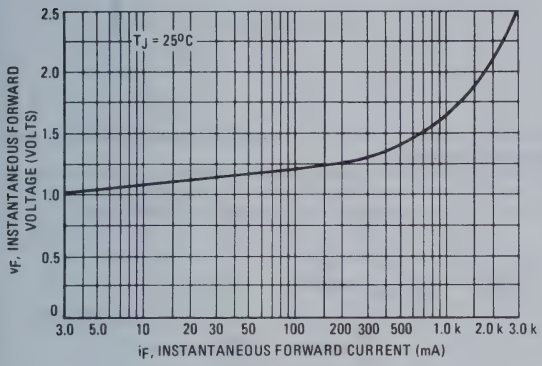


FIGURE 5 – COLLECTOR-EMITTER CUTOFF CURRENT

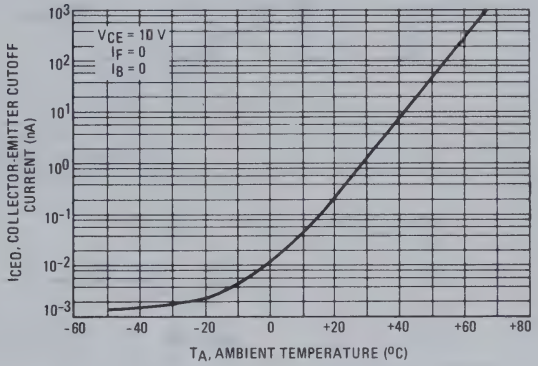


FIGURE 6 – FREQUENCY RESPONSE

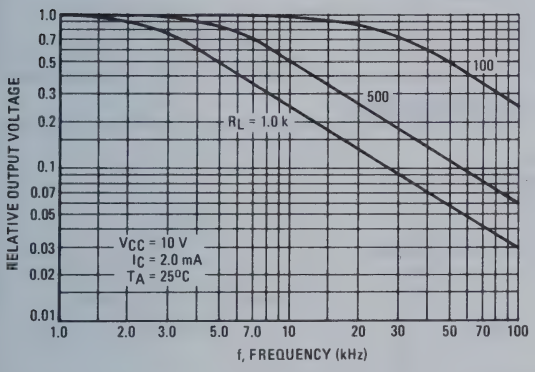


FIGURE 7 – SWITCHING TIMES

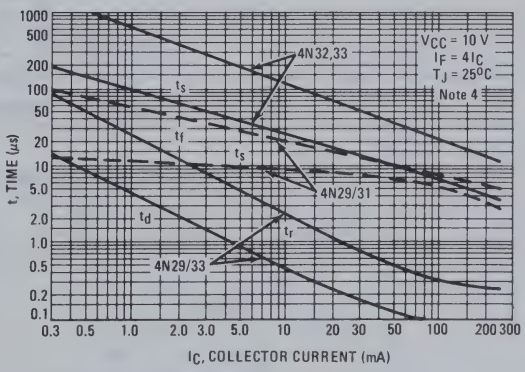


FIGURE 8 – FREQUENCY RESPONSE TEST CIRCUIT

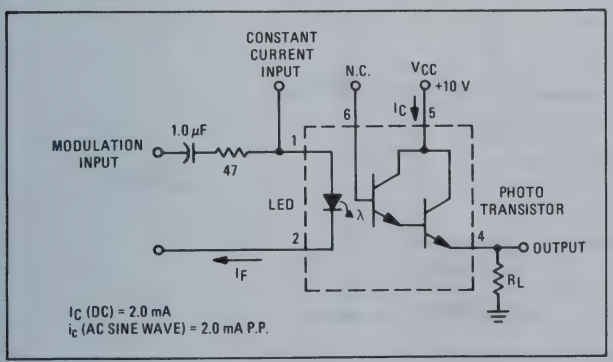
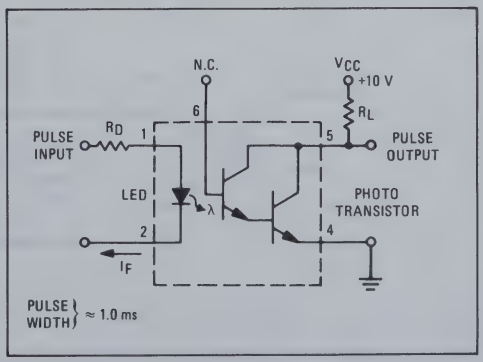


FIGURE 9 – SWITCHING TIME TEST CIRCUIT



TYPICAL APPLICATIONS

FIGURE 10 – VOLTAGE CONTROLLED TRIAC

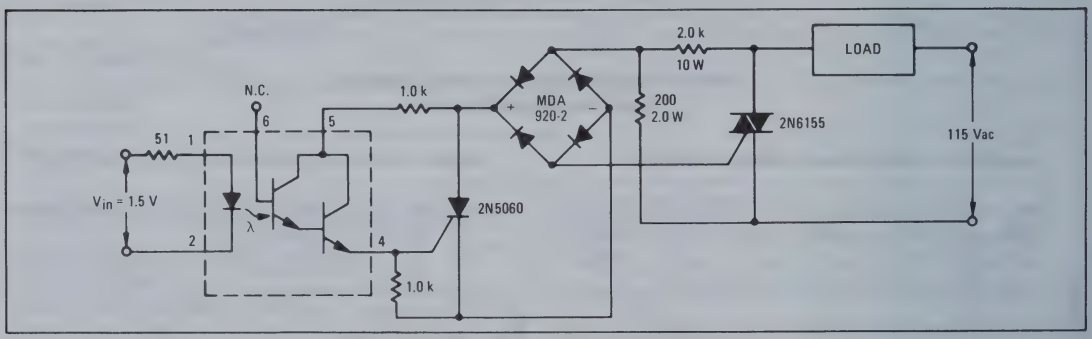


FIGURE 11 – AC SOLID STATE RELAY

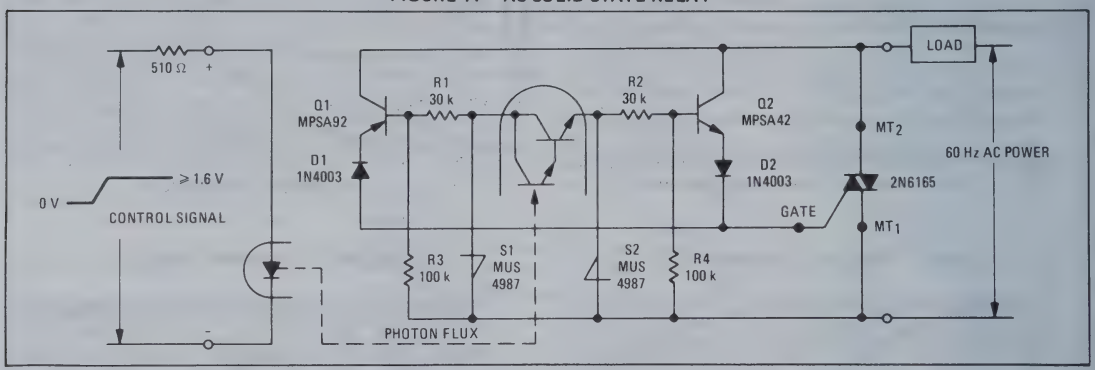


FIGURE 12 – OPTICALLY COUPLED ONE SHOT

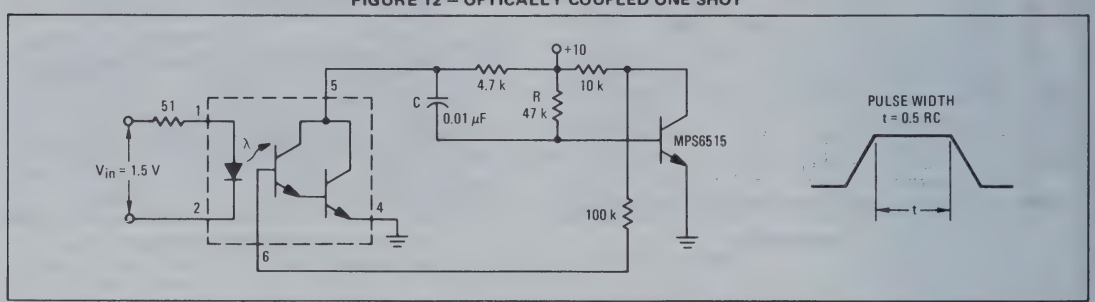
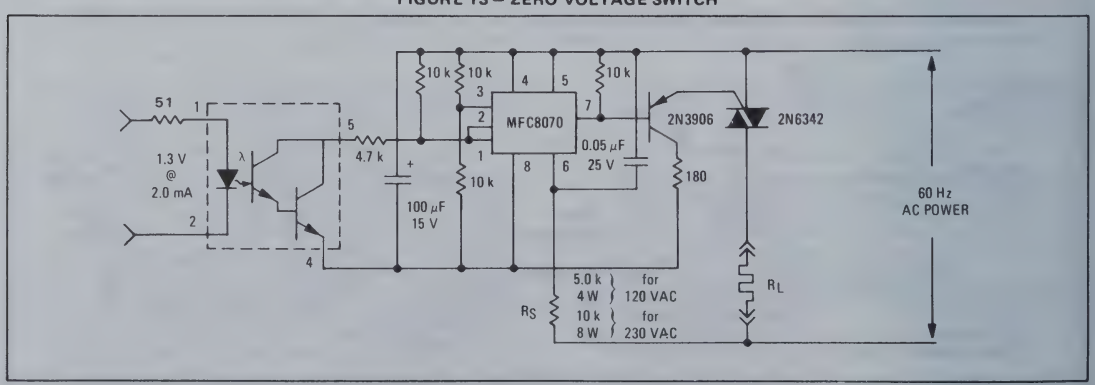


FIGURE 13 – ZERO VOLTAGE SWITCH



IN-HOUSE NUMBERED DEVICE SPECIFICATIONS

DIODES
OPTOELECTRONICS
MODULES
POWER VARACTORS
RECTIFIERS
RECTIFIER ASSEMBLIES
THYRISTORS & TRIGGERS
TRANSISTORS

1/4M2.4AZ thru 1/4M200Z (SILICON)

1/4 W
2.4 — 200 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region. These devices are in the same 400 mW glass package as the 1N746 and 1N957 Series, but designated 1/4 Watt to allow characterization at a different test current level.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 1/4 Watt (Derate 1.67 mW/°C Above 25°C)

The type numbers specified have a standard voltage (V_Z) tolerance of ±20%. For closer tolerances, add suffix "10" for ±10% or "5" for ±5%. (3%, 2%, 1% tolerances also available.)

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc*	
						V_{R1}	V_{R2}
1/4M2.4AZ	2.4	10	60	70	75	1	1
1/4M2.7AZ	2.7	10	60	65	75	1	1
1/4M3.0AZ	3.0	10	55	60	50	1	1
1/4M3.3AZ	3.3	10	55	55	50	1	1
1/4M3.6AZ	3.6	10	50	52	50	1	1
1/4M3.9AZ	3.9	10	50	49	25	1	1
1/4M4.3AZ	4.3	10	45	46	25	1.5	1.5
1/4M4.7AZ	4.7	10	35	42	10	1.5	1.5
1/4M5.1AZ	5.1	10	25	39	5	1.5	1.5
1/4M5.6AZ	5.6	10	20	36	5	1.5	1.5
1/4M6.2AZ	6.2	10	15	33	5	3.5	3.5
1/4M6.8Z	6.8	9.2	7.0	33	150	5.2	4.9
1/4M7.5Z	7.5	8.3	8.0	30	75	5.7	5.4
1/4M8.2Z	8.2	7.6	9.0	26	50	6.2	5.9
1/4M9.1Z	9.1	6.9	10	24	25	6.9	6.6
1/4M10Z	10	6.3	11	21	10	7.6	7.2
1/4M11Z	11	5.7	13	19	5	8.4	8.0
1/4M12Z	12	5.2	15	18	5	9.1	8.6
1/4M13Z	13	4.8	18	16	5	9.9	9.4
1/4M14Z	14	4.5	20	15	5	10.6	10.1
1/4M15Z	15	4.2	22	14	5	11.4	10.8
1/4M16Z	16	3.9	24	13	5	12.2	11.5
1/4M17Z	17	3.7	26	12.5	5	13.0	12.2
1/4M18Z	18	3.5	28	11.5	5	13.7	13.0
1/4M19Z	19	3.3	30	11.0	5	14.4	13.7
1/4M20Z	20	3.1	33	10.5	5	15.2	14.4
1/4M22Z	22	2.8	40	9.5	5	16.7	15.8
1/4M24Z	24	2.6	46	9.0	5	18.2	17.3
1/4M25Z	25	2.5	50	8.0	5	19.0	18.0
1/4M27Z	27	2.3	58	7.5	5	20.6	19.4
1/4M30Z	30	2.1	70	7.0	5	22.8	21.6

*V_{R1} — Test Voltage for 5% Tolerance Device V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA) (continued)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc*	
						V_{R1}	V_{R2}
1/4M33Z	33	1.9	85	6.5	5	25.1	23.8
1/4M36Z	36	1.7	100	6.0	5	27.4	25.9
1/4M39Z	39	1.6	120	5.0	5	29.7	28.1
1/4M43Z	43	1.5	140	4.8	5	32.7	31.0
1/4M45Z	45	1.4	150	4.5	5	34.2	32.4
1/4M47Z	47	1.3	160	4.3	5	35.8	33.8
1/4M50Z	50	1.2	180	4.1	5	38.0	36.0
1/4M52Z	52	1.2	200	4.0	5	39.5	37.4
1/4M56Z	56	1.1	230	3.8	5	42.6	40.3
1/4M62Z	62	1.0	290	3.3	5	47.1	44.6
1/4M68Z	68	0.92	350	3.0	5	51.7	49.0
1/4M75Z	75	0.83	450	2.8	5	56.0	54.0
1/4M82Z	82	0.76	550	2.5	5	62.2	59.0
1/4M91Z	91	0.69	700	2.3	5	69.2	65.5
1/4M100Z	100	0.63	900	2.0	5	76.0	72.0
1/4M105Z	105	0.60	1000	1.9	5	79.8	75.6
1/4M110Z	110	0.57	1200	1.8	5	83.6	79.2
1/4M120Z	120	0.52	1500	1.7	5	91.2	86.4
1/4M130Z	130	0.48	1900	1.5	5	98.8	93.6
1/4M140Z	140	0.45	2200	1.4	5	106.4	100.8
1/4M150Z	150	0.42	2500	1.3	5	114.0	108.0
1/4M175Z	175	0.36	3300	1.1	5	133.0	126.0
1/4M200Z	200	0.31	4300	1.0	5	152.0	144.0

*V_{R1} – Test Voltage for 5% Tolerance Device V_{R2} – Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 – Nominal zener voltages between those shown.

2 – Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 – Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2360
MZ2361
MZ2362

CONSTANT-VOLTAGE REFERENCE DIODES FOR LOW-VOLTAGE APPLICATIONS

. . . high-conductance silicon diodes designed as a stable forward reference source for biasing transistor amplifiers and similar applications.

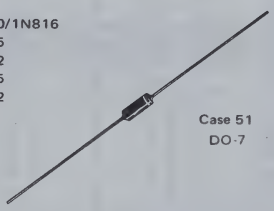
- Guaranteed Forward Voltage Range
- Choice of Package
- Temperature Effects Provided

FORWARD REFERENCE DIODES — STABISTORS —

MAXIMUM RATINGS

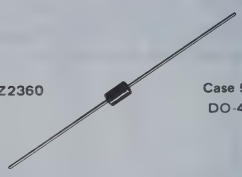
Rating	Symbol	Value	Unit
DC Power Dissipation @ T_L = 30°C ±3°C, Lead Length = 3/8"	P_D	400	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2361
MZ2362



Case 51
DO-7

MZ2360



Case 59
DO-41

MECHANICAL CHARACTERISTICS

Case: Choice of package, either Glass or Surmetic

Dimensions: See outline drawings

Finish: All external surfaces are corrosion resistant and leads are readily solderable and weldable

Polarity: Cathode indicated by polarity band. Cathode negative for forward reference application.

Weight: 0.2 Gram (approximate)

Mounting Positions: Any

.4M.64FR10/1N816, .4M1.36FR5, .4M1.36FR2, .4M2.04FR5, .4M2.04FR2, MZ2360, MZ2361, MZ2362 (continued)

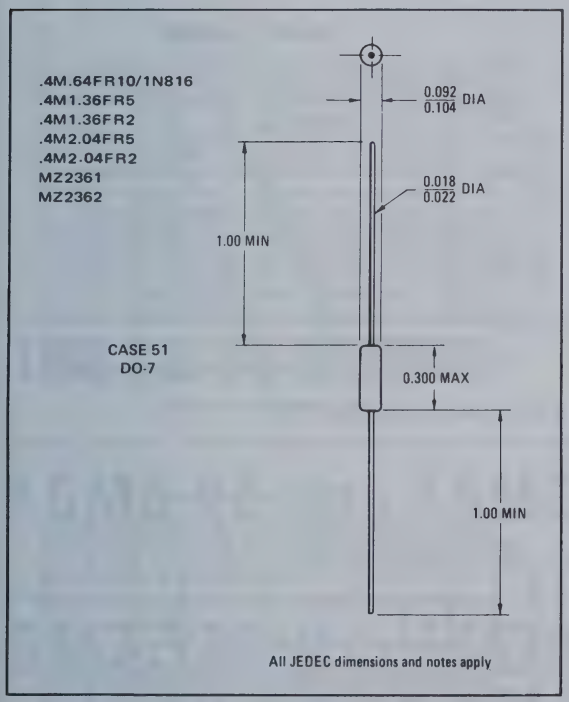
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

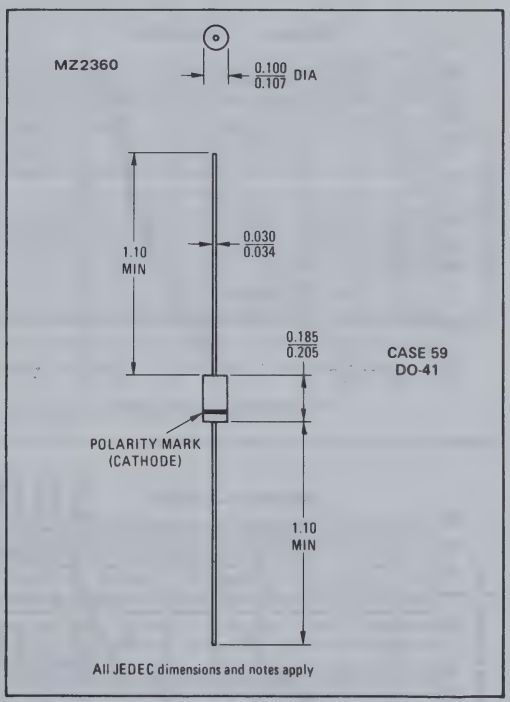
Type Number	Forward Reference Voltage (1) @		Reverse Leakage Current (Max) @		Package	Case
	V_F Volts Min/Max	I_F mA	I_R μA	V_R Volts		
.4M.64FR10/ 1N816* (2)	0.58/0.70	1.0	0.1	4.0	Glass	51
.4M1.36FR5	1.29/1.43	10	0.1	4.0	Glass	51
.4M1.36FR2	1.33/1.39	10	0.1	4.0	Glass	51
.4M2.04FR5	1.94/2.14	10	0.1	4.0	Glass	51
.4M2.04FR2	2.00/2.08	10	0.1	4.0	Glass	51
MZ2360	0.63/0.71	10	10	5.0	Surmetic	59
MZ2361	1.24/1.38	10	10	5.0	Surmetic	51
MZ2362	1.90/2.10	10	10	5.0	Glass	51

*Indicates JEDEC Registered Data for 1N816

(1) Motorola guarantees the forward reference voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at 30°C ± 1°C, 3/8" from the diode body.

(2) Minimum Saturation Voltage for 1N816 = 40 V @ 100 μA.





TYPICAL FORWARD VOLTAGE CHARACTERISTICS

FIGURE 1 – .4M.64FR10/1N816

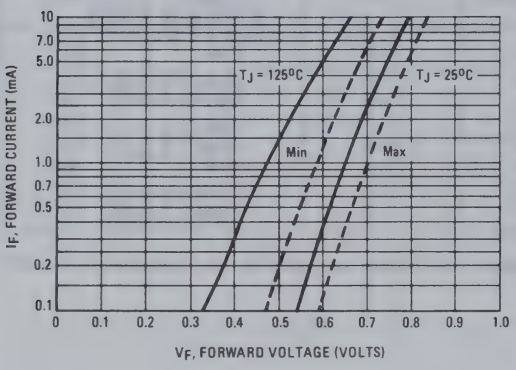


FIGURE 2 – .4M1.36FR5

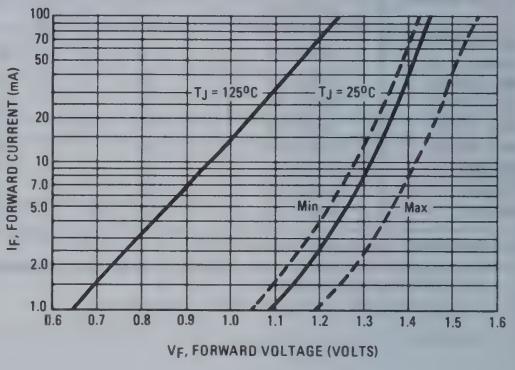


FIGURE 3 – .4M2.04FR5

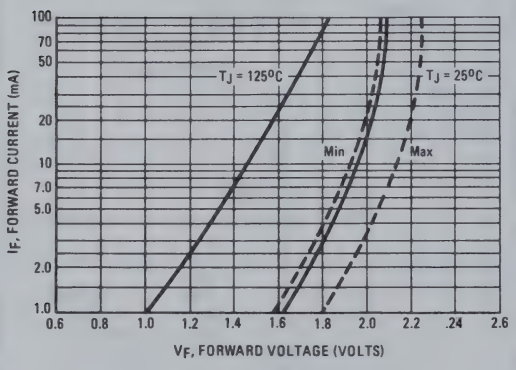


FIGURE 4 – MZ2360

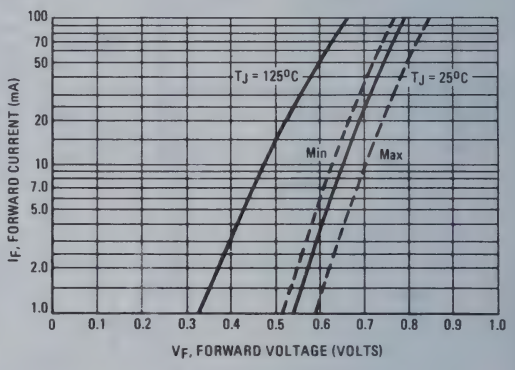


FIGURE 5 – MZ2361

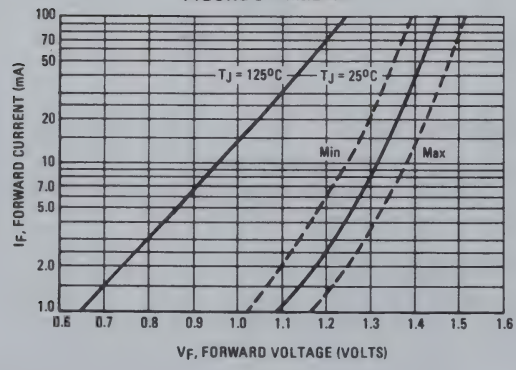
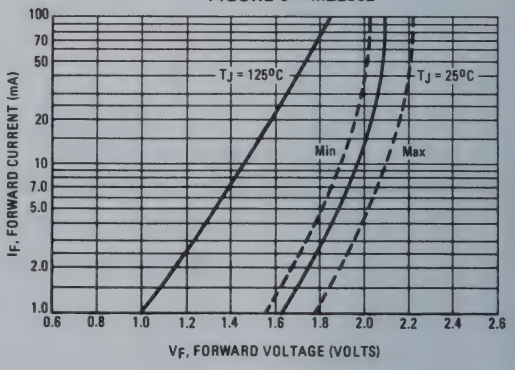


FIGURE 6 – MZ2362



.4M.64FR10/1N816, 4M1.36FR5, .4M1.36FR2, .4M2.04FR5, .4M2.04FR2, MZ2360, MZ2361, MZ2362 (continued)

TYPICAL TEMPERATURE COEFFICIENT

FIGURE 7 – .4M.64FR10/1N816

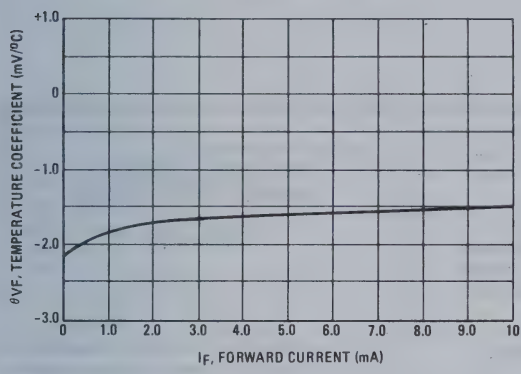


FIGURE 8 – MZ2360

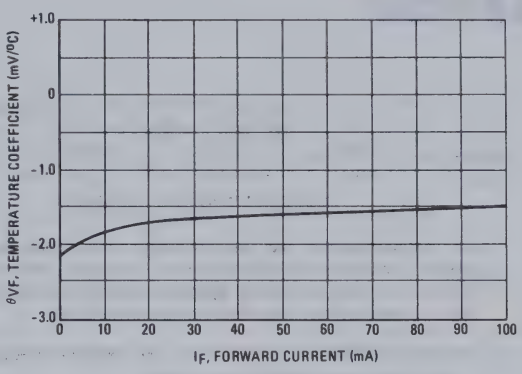


FIGURE 9 – .4M1.36FR5/MZ2361

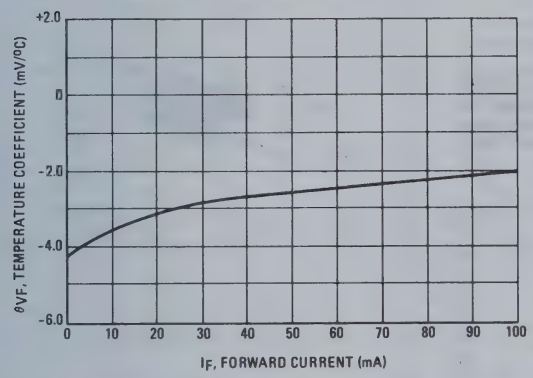
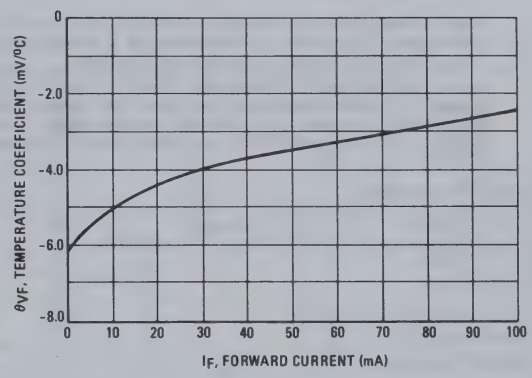


FIGURE 10 – .4M2.04FR5/MZ2362



1M3.3ZS thru 1M200ZS

For Specifications, See 1N4728 Data, Volume 1.

1.5M6.8Z thru 1.5M200Z

For Specifications, See 1N3785 Data, Volume I.

5M3.3ZS thru 5M200ZS

For Specifications, See 1N5333 Data

10M6.8Z thru 10M200Z

For Specifications, See 1N2970 Data, Volume I.

50M3.9Z thru 50M200Z

For Specifications, See 1N2804 Data, Volume I.

BB105A (SILICON)
BB105B
BB105G

VVC

SILICON EPICAP DIODES

. . . designed in the new low-inductance mini-L package for high volume requirements of UHF and VHF TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Guaranteed Minimum Q Values at VHF and UHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

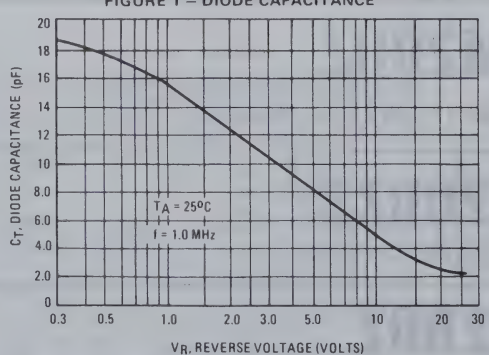
*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to your specified conditions along the entire tuning range.

If you require BB105B matched to ±1.5% between 3.0 and 25 Volts, add "M" to the device title (i.e., BB105BM). BB105A and BB105 can be ordered matched to ±3.0% by adding M to the device title. Matched units can be supplied with a minimum of 12 matched units per package. For any other matched tolerances or conditions, please contact your local Motorola Representative.

MAXIMUM RATINGS

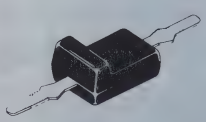
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

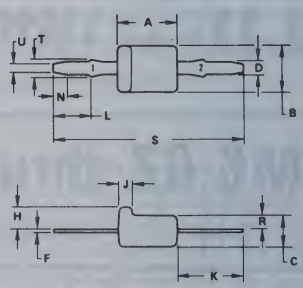
FIGURE 1 – DIODE CAPACITANCE



VOLTAGE VARIABLE CAPACITANCE DIODES

30 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

PIN 1. CATHODE
2. ANODE

CASE 226

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic-All Types	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	Vdc
Reverse Voltage Leakage Current (VR = 28 V) (VR = 28 V) T_A = 60°C	I_R	–	50.0 0.5	nAdc μAdc
Series Inductance (f = 250 MHz)	L_S	–	3.0	nH
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	400	ppm/°C

Device Type	C_T V_R = 25 Vdc pF		Q f = 100 MHz C_T = 9 pF	R_S Ohms	C_3/C_{25}		Package Stripe
	Min	Max	Min	Max	Min	Max	Color
BB105A	2.3	2.8	225	0.8	4.0	5	Blue
BB105B	2.0	2.3	225	0.8	4.5	6	Yellow
BB105G	1.8	2.8	150	1.2	4.0	6	Green

FIGURE 2 – FIGURE OF MERIT

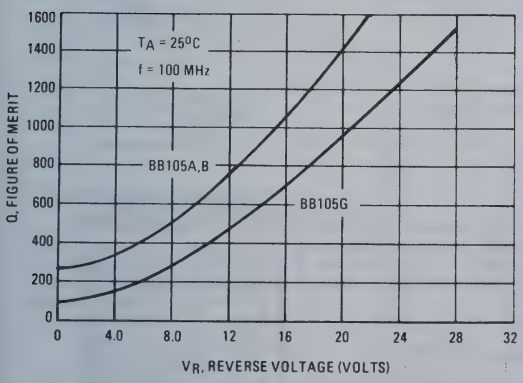
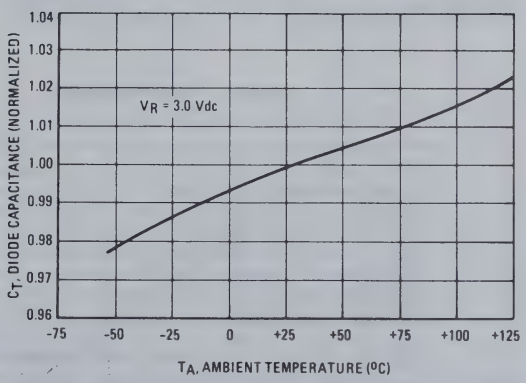


FIGURE 3 – DIODE CAPACITANCE



BU108 (SILICON)

MJ3480

HORIZONTAL DEFLECTION SILICON TRANSISTORS

. . . designed for use in large screen color television receivers.

- Collector-Emitter Voltage — V_{CER} = 1500 Vdc
- Collector Current — I_C = 5.0 Adc
- Fall Time @ I_C = 4.5 Adc — t_f = 0.7 μs (Typ) • t_f = 1.0 μs (Max)

5.0 AMPERE

TRIPLE DIFFUSED POWER TRANSISTORS NPN SILICON

1300, 1500 VOLTS
56 WATTS



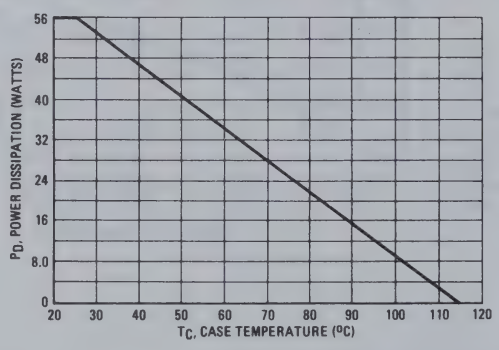
MAXIMUM RATINGS

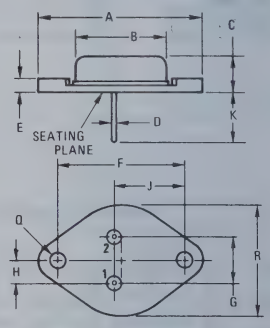
Rating	Symbol	BU108	MJ3480	Unit
Collector-Emitter Voltage	V_{CEO}	750	700	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	1500	1300	Vdc
Collector-Base Voltage	V_{CB}	1500	1300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	Vdc
Collector Current — Continuous — Peak	I_C	5.0 10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	56 0.625		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +115		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.6	°C/W

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

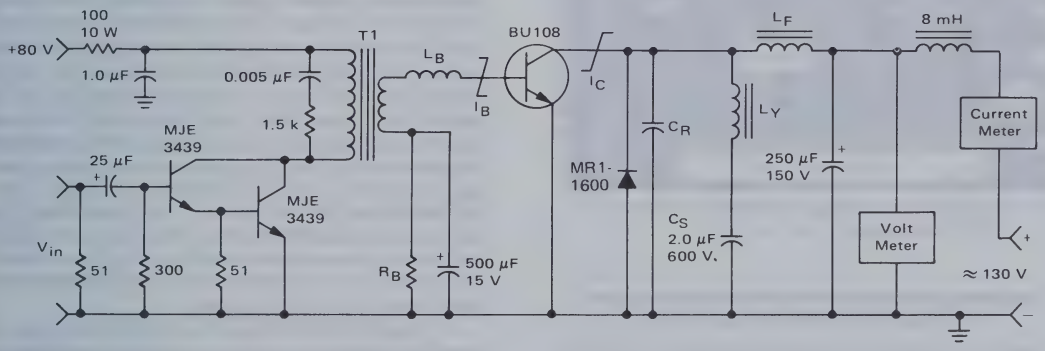
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	BU108	$V_{CEO(sus)}$	750	–	–	Vdc
	MJ3480		700	–	–	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 1500 Vdc, V_{BE} = 0)	BU108		–	–	1.0	
(V_{CE} = 1300 Vdc, V_{BE} = 0)	MJ3480		–	–	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	1.0	mAdc
ON CHARACTERISTICS						
Collector-Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2.0 Adc)		$V_{CE(sat)}$	–	–	5.0	Vdc
Base Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2.0 Adc)		$V_{BE(sat)}$	–	–	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased (t = 1.0 s, V_{CE} = 100 Vdc)		$I_{S/b}$	200	–	–	mAdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (2) (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)		f_T	–	7.5	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	125	–	pF
SWITCHING CHARACTERISTICS						
Fall Time (I_C = 4.5 Adc, I_{B1} = 1.8 Adc, L_B = 10 μH, See Figure 2)		t_f	–	0.7	1.0	μs

(1) Pulse Test: Pulse Width 300 μs, Duty Cycle ≈ 2.0%

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – TEST CIRCUIT



DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance–39 mH, Secondary Inductance–0.22 mH, Leakage inductance with primary shorted–2.0 μH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

I_C A	L_F mH	L_Y mH	C_R μF
3.5	1.8	2.5	0.0133
4.5	1.0	2.5	0.02

TEST CIRCUIT OPTIMIZATION

The test circuit and operating waveforms for the BU108 and MJ3480 transistors are shown in Figures 2 and 3. The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance. Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

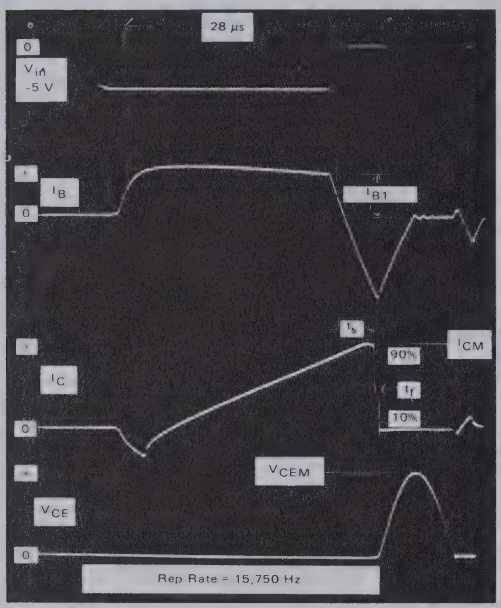
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 2, is voltage capability. The flyback voltage that the device will be subjected to is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, shown in Figure 3, will usually be 8 times the 130-volt power supply voltage or approximately 1000 volts, but may be varied slightly by adjusting retrace time and flyback tuning. For this reason, high voltage devices are particularly useful in cost conscious solid-state receivers as they permit the use of an off-the-line half wave power supply.

The power supply used in the circuit of Figure 2, was chosen to produce approximately a 1000 V collector pulse on the transistor, a conservative value, recommended for unregulated applications.

The values of yoke inductance (L_Y), flyback primary inductance (L_F), retrace capacitor (C_R) and "S" shaping capacitor (C_S) are shown for operating collector currents of 3.5 A which is suitable for 90° color and 110° large screen black and white receivers, and 4.5 A for 110° color receivers. Peak collector currents to 10 A may be handled by these transistors. The most efficient application results when the power supply voltage is held constant. Adjustments of the amount of deflection can then be made by raising or lowering L_Y and L_F. $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y\sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 3 – TEST CIRCUIT WAVEFORMS

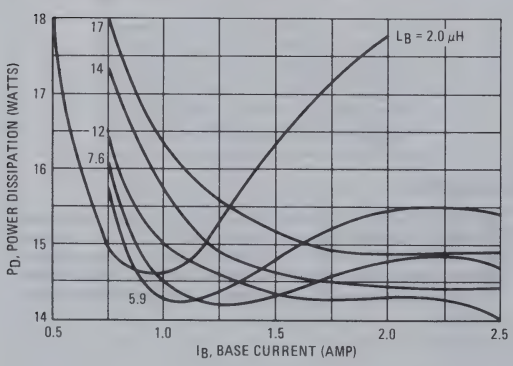


Fundamental waveforms of a simplified horizontal deflection circuit.

TEST CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or plastic power type will generally be needed. For testing convenience, the Darlington arrangement of the driver transistor shown in Figure 2 was used to produce a wide range of I_{B1} current values. Once the driver circuitry is chosen, the turns ratio of the driver transformer can be selected to produce 4 to 5 volts peak-to-peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low AC impedance for good turn-off of the output device.

FIGURE 4 – RELATIONSHIP OF POWER DISSIPATION TO L_B WITH CHANGING I_{B1}, I_{CM} = 4.5 A



In Figure 4, the effects of varying L_B and I_{B1} on total power input to a deflection circuit requiring an I_C of 4.5 A are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 4 is 12 μH. This is the sum of the actual leakage inductance of the driver transformer (secondary inductance with primary shorted) and an external L if necessary. The value of I_{B1} is approximately 1.75 A achieved in a typical device by using R_B = 2.3 Ω, which was derived experimentally. These are the choices recommended for the test fixture when the transistor is used at I_{CM} = 4.5 A.

Today many TV receivers operate with an I_{CM} of approximately 3.5 A, Figure 8 shows the relationship of power dissipation to L_B, with changing I_{B1}, when I_C of 3.5 A is required.

The best value of L_B, found in Figure 9 is 22 μH. This value is the sum of the driver transformer leakage inductance and an external inductance if necessary. The best value of I_{B1} is approximately 1.15 A, with an R_B of 3.2 Ω. These are the choices recommended for the test fixture when the transistor is used at I_{CM} = 3.5 A.

For other values of I_{CM} the drive circuit components must be changed. Figures 5, 6 and 7 show the values of L_B and I_{B1} which should be used. The value of R_B which will be required to produce the corresponding I_{B1} is also given, but, it is not an independent variable.

PERFORMANCE

Shown in Figures 9 and 10 are the typical results that will be obtained with the test circuit at various operating conditions.

INTERRELATION OF BASE RESISTANCE, BASE INDUCTANCE AND BASE CURRENT

FIGURE 5 – OPTIMUM BASE RESISTANCE

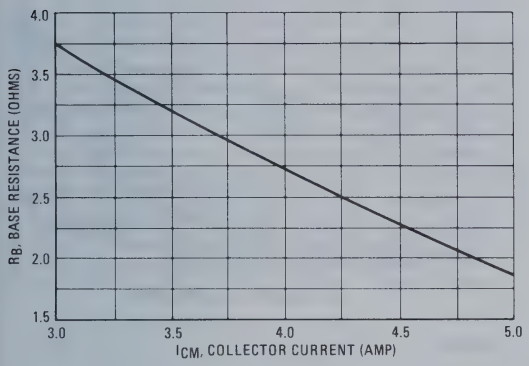


FIGURE 6 – OPTIMUM BASE INDUCTANCE

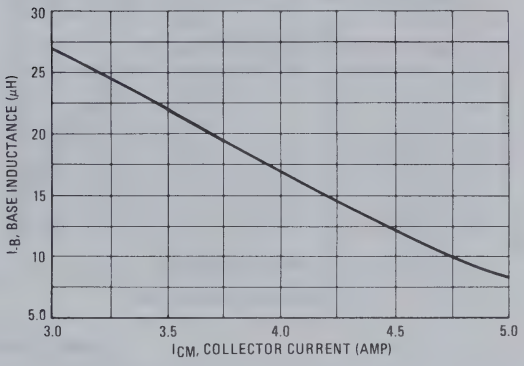


FIGURE 7 – OPTIMUM BASE CURRENT

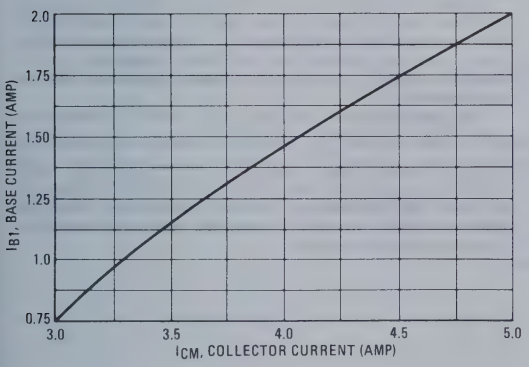


FIGURE 8 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_{CM} = 3.5 A

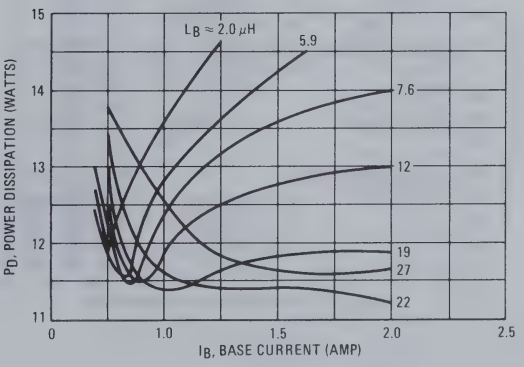


FIGURE 9 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

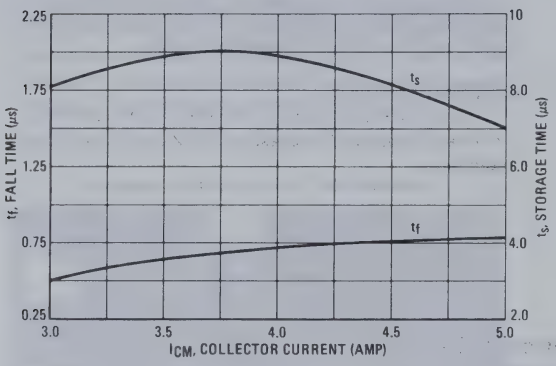


FIGURE 10 – EFFECT OF COLLECTOR CURRENT ON INPUT POWER

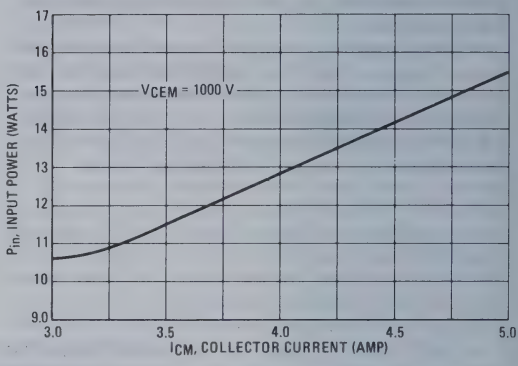


FIGURE 11 – DC CURRENT GAIN

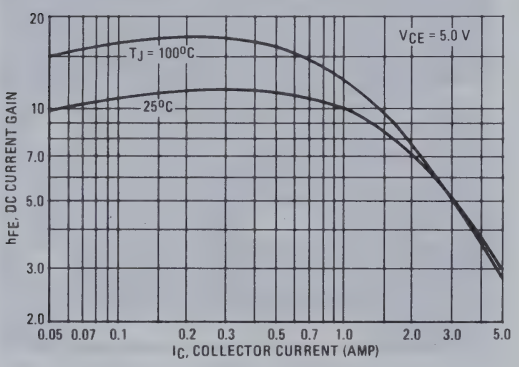


FIGURE 12 – "ON" VOLTAGES

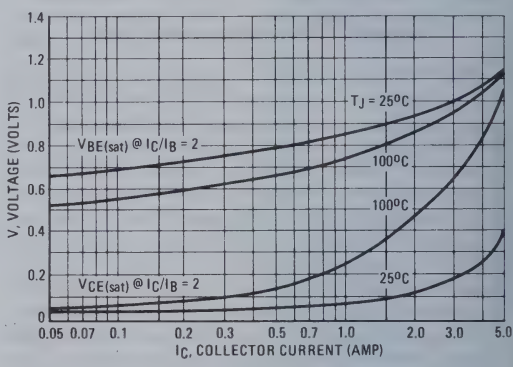
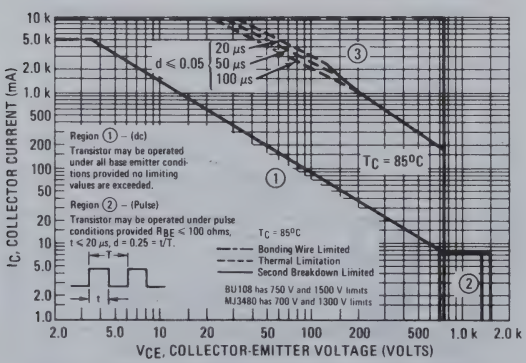


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on T_C = 85°C. Thermal pulse limits shown in region (3) are valid for a duty cycle of 5.0%. For other conditions, $T_{J(pk)}$ must be calculated and kept below 115°C. $T_{J(pk)}$ may be calculated from the data of Figure 14. At higher case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitation imposed by second breakdown.

FIGURE 14 – THERMAL RESPONSE

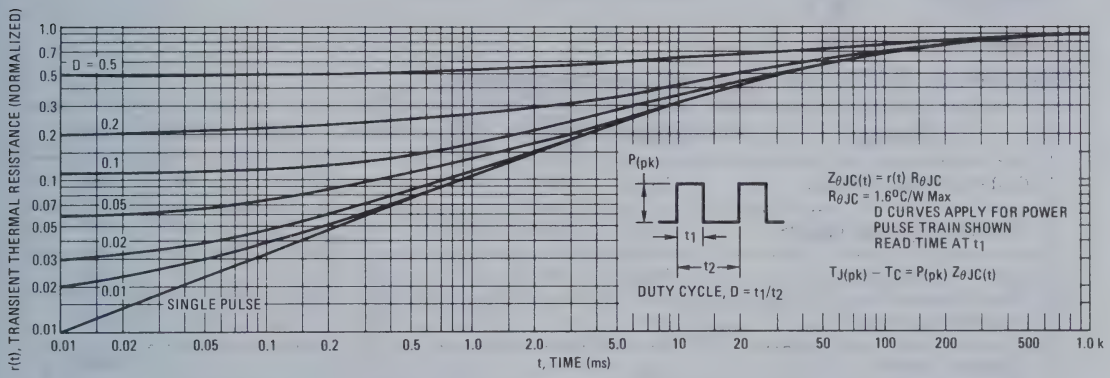


FIGURE 15 – COLLECTOR CUT-OFF REGION

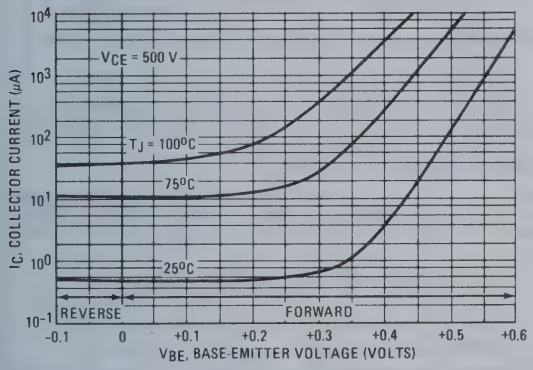


FIGURE 16 – COLLECTOR-BASE LEAKAGE CURRENT

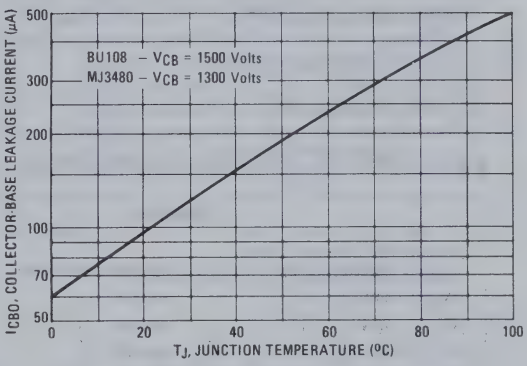
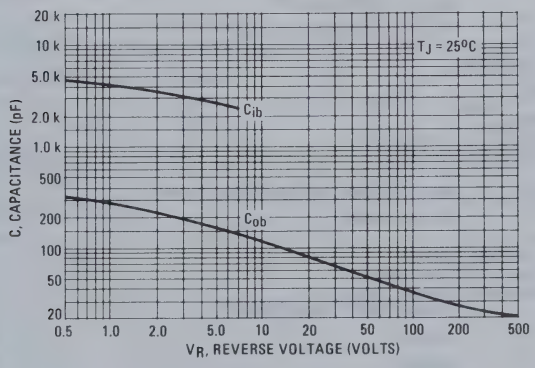


FIGURE 17 – CAPACITANCE



MA200 thru MA206 (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated from case

Germanium PNP transistor designed for high-voltage applications in the audio frequency range, such as neon driver, solenoid or relay driver applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MA200 MA202	MA201 MA203	MA204	MA205	MA206	Unit
Collector-Base Voltage	V_{CB}	105	105	90	75	60	Vdc
Collector-Emitter Voltage	V_{CE}	105	105	90	75	60	Vdc
Emitter-Base Voltage	V_{EB}	10	20	20	20	10	Vdc
Collector Current	I_C	200					mAdc
Emitter Current	I_E	200					mAdc
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +100					°C
Thermal Resistance	θ_{JA}	0.5					°C/mW
Collector Dissipation at T_A = 25°C Derate above 25°C	P_D	150 2.0					mW mW/°C

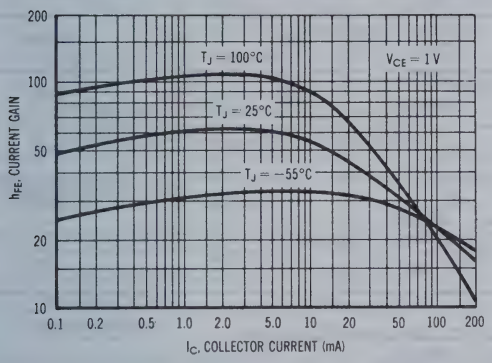
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μA
(V_{CB} = 105 V, I_E = 0)	MA 200 thru MA203					
(V_{CB} = 90 V, I_E = 0)	MA204		—	12.0	50	
(V_{CB} = 75 V, I_E = 0)	MA205					
(V_{CB} = 60 V, I_E = 0)	MA206					
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_E = 0)		I_{CBO}	—	5.0	14	μA
Emitter-Base Cutoff Current		I_{EBO}				μA
(V_{EB} = 10 V, I_C = 0)	MA200, MA202, MA206		—	3.0	50	
(V_{EB} = 20 V, I_C = 0)	MA201, MA203, MA204, MA205		—	3.0	50	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	0.22	0.40	Vdc
DC Current Gain		h_{FE}				—
(I_C = 5 mAdc, V_{CE} = 0.35 Vdc)	MA200, MA201, MA204, MA205, MA206		20	—	—	
	MA202, MA203		40	—	—	
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})		V_{PT}				Vdc
	MA200, MA201, MA202, MA203		105	—	—	
	MA204		90	—	—	
	MA205		75	—	—	
	MA206		60	—	—	
Small-Signal Short-Circuit Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)		$f_{\alpha b}$	—	1.0	—	MHz

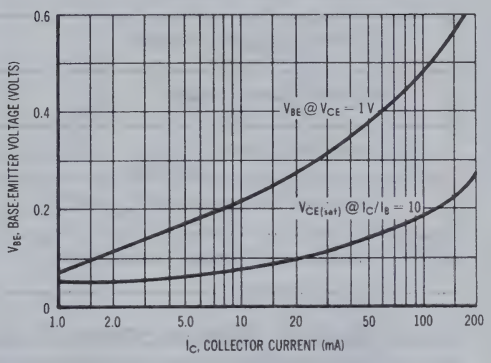
DC CHARACTERISTICS

(T_J = 25°C unless otherwise noted)

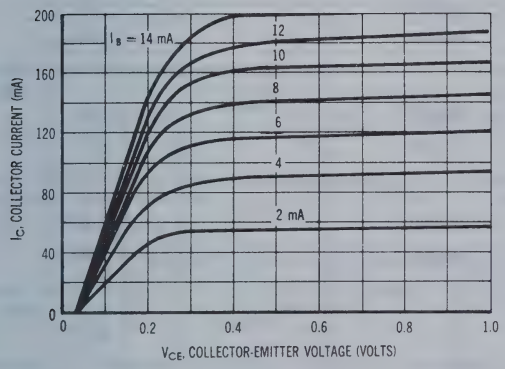
CURRENT GAIN



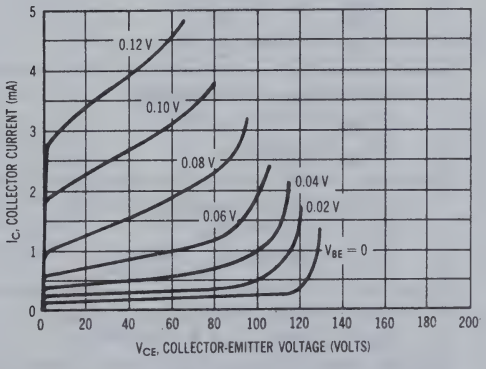
"ON" VOLTAGES



COLLECTOR SATURATION REGION



COLLECTOR HIGH VOLTAGE REGION



MA909 thru MA910 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case

PNP Germanium transistors for high-voltage neon driver, solenoid and relay driver circuits.

MAXIMUM RATINGS

Rating	Symbol	MA909	MA910	Unit
Collector-Base Voltage	V_{CB}	75	90	Volts
Collector-Emitter Voltage	V_{CEO}	75	90	Volts
Emitter-Base Voltage	V_{EB}	35	45	Volts
Collector Current	I_C	200		mA
Collector Dissipation at $T_C = 25°C$	P_D	150		mW
Junction and Storage Temperature	T_J, T_{stg}	100		°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			Adc
(V_{CB} = 2.5 Vdc, I_E = 0)	Both Types		-	14	
(V_{CB} = 75 Vdc, I_E = 0)	MA909		-	50	
(V_{CB} = 90 Vdc, I_E = 0)	MA910		-	50	
Emitter-Base Cutoff Current		I_{EBO}			Adc
(V_{EB} = 35 Vdc, I_C = 0)	MA909		-	50	
(V_{EB} = 45 Vdc, I_C = 0)	MA910		-	50	
Collector-Emitter Leakage Current		I_{CES}			Adc
(V_{CE} = 75 Vdc, R_{BE} = 0)	MA909		-	100	
(V_{CE} = 90 Vdc, R_{BE} = 0)	MA910		-	100	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	-	0.40	Vdc
DC Current Gain (I_C = 5 mAdc, V_{CE} = 0.35 Vdc)		h_{FE}	20	-	-
Collector-Emitter Punch-Thru Voltage		V_{pt}			Vdc
(V_{fl} = 1.0 Vdc, R_{in} of VTVM - 10 to 12 Megohms)	MA909		75	-	
	MA910		90	-	

MA4404, MA4404A (GERMANIUM)
MM4404, MM4404A

PNP GERMANIUM SWITCHING TRANSISTORS

. . . designed for medium-speed saturated switching and chopper applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 24 mAdc – All Types
  = 0.25 Vdc (Max) @ I_C = 200 mAdc – MA4404,A
- High Emitter-Base Breakdown Voltage @ I_E = 100 μAdc –
  BV_{EBO} = 12 Vdc (Min) – MM4404, MA4404
  = 25 Vdc (Min) – MM4404A, MA4404A
- High Alpha Cutoff Frequency –
  f_{hfb} = 4.0 MHz (Min) @ I_E = 1.0 mAdc – MM4404,A
- MA4404, MA4404A Series Germanium Alloy
- MM4404, MM4404A Series Germanium Mesa

PNP GERMANIUM SWITCHING TRANSISTORS

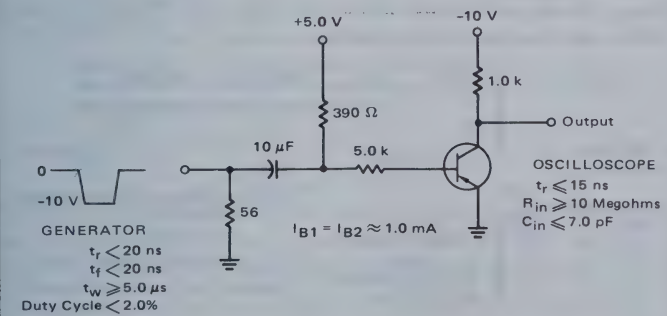
MAXIMUM RATINGS

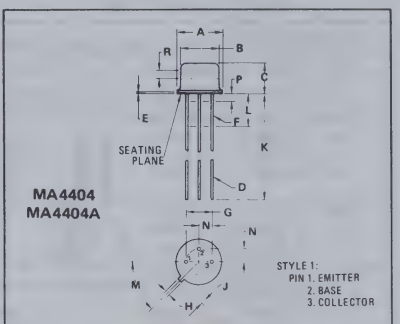
Rating	Symbol	MA4404 MM4404	MA4404A MM4404A	Unit
Collector-Emitter Voltage	V_{CES}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
		MA4404 MA4404A	MM4404 MM4404A	
Collector Current-Continuous	I_C	350	250	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.67	150 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0	250 3.33	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← −65 to +100 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MA4404 MA4404A	MM4404 MM4404A	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	375	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	300	°C/W

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT

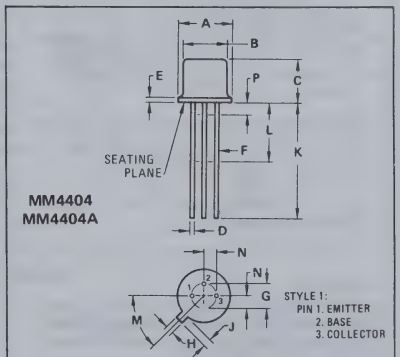




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

CASE 031-03
TO-5

All Leads Isolated from Case



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	

CASE 22
TO-18

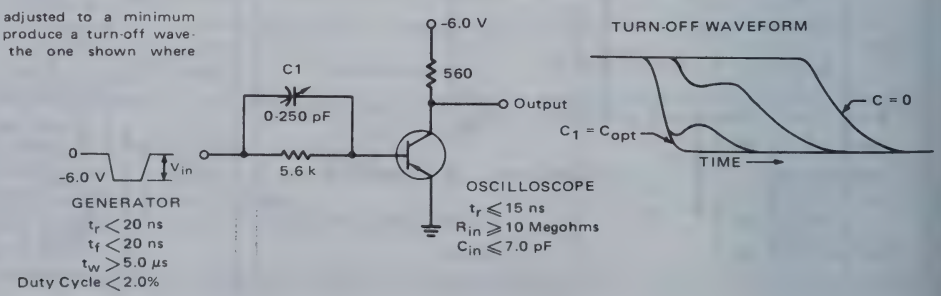
All Leads Isolated from Case

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	MA4404, MM4404	BV_{CES}	24	–	–	Vdc
	MA4404A, MM4404A		35	–	–	
Collector-Base Breakdown Voltage (I_C = 20 μAdc, I_E = 0)	MA4404, MM4404	BV_{CBO}	25	–	–	Vdc
	MA4404A, MM4404A		40	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	MA4404, MM4404	BV_{EBO}	12	–	–	Vdc
	MA4404A, MM4404A		25	–	–	
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	MA4404,A	I_{CBO}	–	–	10	μAdc
	MM4404,A		–	–	5.0	
(V_{CB} = 12 Vdc, I_E = 0, T_A = 80°C)	All Types		–	–	500	
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	0.5	5.0	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.2 Vdc)		h_{FE}	30	80	–	–
(I_C = 24 mAdc, V_{CE} = 0.2 Vdc)			24	70	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 12 mAdc, I_B = 0.4 mAdc)	All Types		–	0.09	0.20	
(I_C = 24 mAdc, I_B = 1.0 mAdc)	All Types		–	0.09	0.20	
(I_C = 200 mAdc, I_B = 20 mAdc)	MA4404,A		–	0.13	0.25	
	MM4404,A		–	0.35	0.45	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 12 mAdc, I_B = 0.4 mAdc)			–	0.27	0.38	
(I_C = 24 mAdc, I_B = 1.0 mAdc)			–	0.30	0.40	
SMALL-SIGNAL CHARACTERISTICS						
Alpha Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)	MA4404,A	f_{hfb}	1.0	2.0	–	MHz
	MM4404,A		4.0	25	–	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)	MA4404	C_{ob}	–	–	25	pF
	MM4404		–	–	20	
(V_{CB} = 6.0 Vdc, I_E = 1.0 mAdc, f = 2.0 MHz)	MA4404A		–	4.0	25	
	MM4404A		–	4.0	20	
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{ie}	–	4.0	–	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{re}	–	8.5	–	$X10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	–	145	–	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{oe}	–	50	–	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (V_{CC} = 10 Vdc, $I_C \approx$ 10 mAdc)	MA4404	t_d	–	0.13	–	μs
	MM4404		–	0.07	–	
Rise Time ($V_{BE(off)}$ = 5.0 Vdc, $I_{B1} \approx$ 1.0 mAdc) (Figure 1)	MA4404	t_r	–	0.40	–	μs
	MM4404		–	0.12	–	
Storage Time (V_{CC} = 10 Vdc, $I_C \approx$ 10 mAdc, $I_{B1} = I_{B2} \approx$ 1.0 mAdc) (Figure 1)	MA4404	t_s	–	1.10	–	μs
	MM4404		–	0.20	–	
Fall Time	MA4404	t_f	–	0.60	–	μs
	MM4404		–	0.10	–	
Total Control Charge (Figure 2)	MA4404	Q_T	–	3000	3600	pC
	MM4404		–	500	1400	

FIGURE 2 – TOTAL CONTROL CHARGE TEST CIRCUIT

Capacitor C_1 is adjusted to a minimum value which will produce a turn-off waveform similar to the one shown where
$C_1 = C_{opt}$
$Q_T = C_{opt} V_{in}$



MAC5 SERIES (SILICON)
MAC6 SERIES



SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

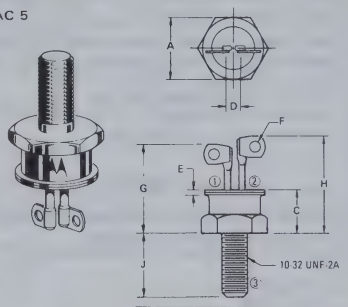
- Glass Passivated Junctions
- Low "on" Voltage – V_{TM} = 1.3 V (Typ) @ 14 A Peak
- Four Mode and Isolated Stud Versions Available (2N6139 Series)

TRIACS (THYRISTORS)

10 AMPERES RMS

25 THRU 600 VOLTS

MAC 5



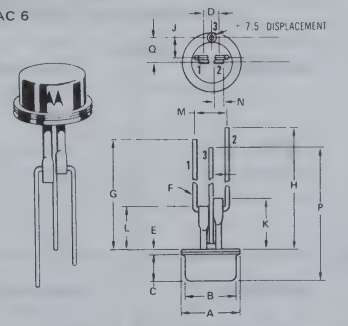
STYLE 2
PIN 1 GATE
2 MAIN TERMINAL 1
3 MAIN TERMINAL 2

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A		0.437	–	11.100
C		0.310	–	7.870
D	0.090	0.110	2.290	2.790
E	0.030	0.050	0.762	1.270
F	0.070 TYP		1.780 TYP	
G		0.610	–	15.490
H		0.660	–	16.760
J	0.422	0.452	10.720	11.480

CASE 86

NOTE
1. DIM. "D" MEASURED AT CAN.

MAC 6



STYLE 2:
PIN 1. GATE
2. MAIN TERMINAL 1
3. MAIN TERMINAL 2

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	–	0.430	–	10.920
B	–	0.350	–	8.890
C	–	0.185	–	4.700
D	0.090	0.110	2.290	2.790
E	0.030	0.050	0.762	1.270
F	0.030	0.034	0.762	0.864
G	1.240 TYP		31.500 TYP	
H	1.320	–	33.530	–
J	0.135	0.145	3.430	3.680
K		0.320	–	8.130
L	–	0.270	–	6.860
M	0.190	0.210	4.830	5.330
N	0.065	0.075	1.650	1.910
P	1.200	–	30.480	–
Q	0.180	0.200	4.570	5.080

CASE 87L

NOTES:
1. DIM. "D" MEASURED AT CAN

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 100°C)	V_{DRM}		Volts
–1		25	
–2		50	
–3		100	
MAC5 and MAC6 –4		200	
–5		300	
–6		400	
–7		500	
–8		600	
On-State Current RMS (T_C = 75°C)	$I_{T(RMS)}$	10	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Peak Gate Power	P_{GM}	10	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque, MAC5	–	15	in. lb.

(1) Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

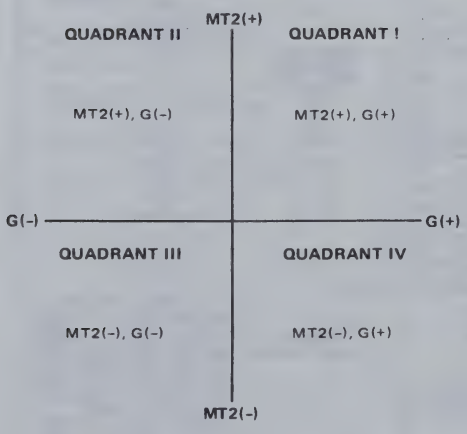
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	50	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ $T_J = 100^oC$, Gate Open	I_{DRM}	–	–	2.0	mA
On-State Voltage (Either Direction) I_{TM} = 14 A Peak	V_{TM}	–	1.3	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	–	50	mA
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	2.5	Volts
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, $T_J = 100^oC$	V_{GD}	0.2	–	–	Volts
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 100 mA	I_H	–	–	50	mA
Turn-On Time I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{on}	–	1.5	–	μs
Blocking Voltage Application Rate at Commutation @ V_{DRM}, $T_J = 75^oC$, Gate Open	dv/dt	–	5.0	–	V/μs

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient = 0.02%/^oC Typ			

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

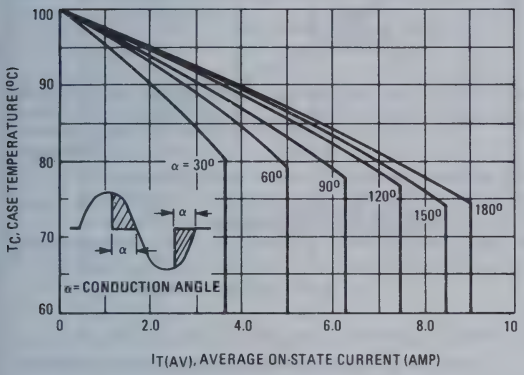


FIGURE 2 – RMS CURRENT DERATING

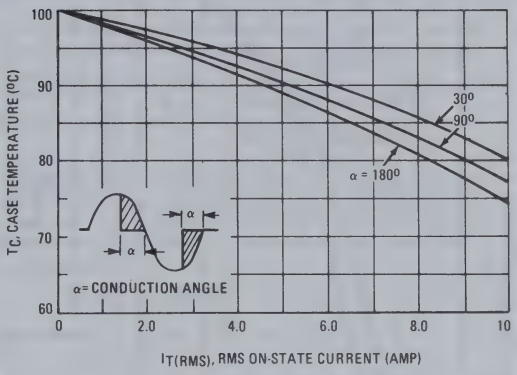


FIGURE 3 – POWER DISSIPATION

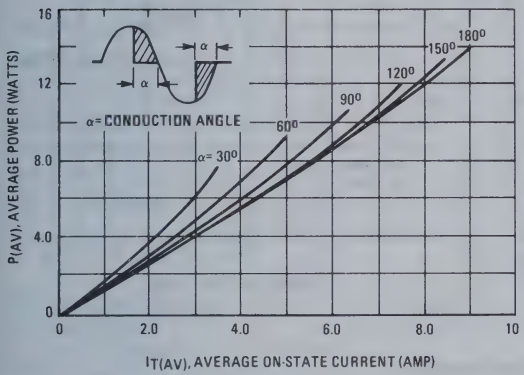


FIGURE 4 – POWER DISSIPATION

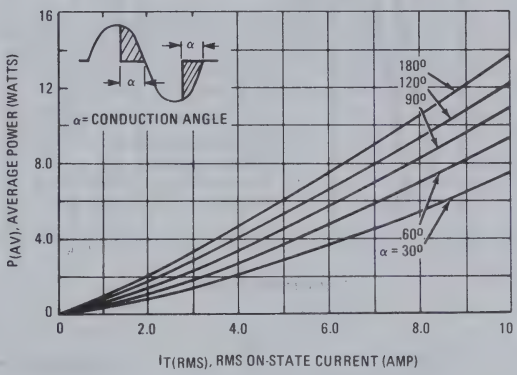


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

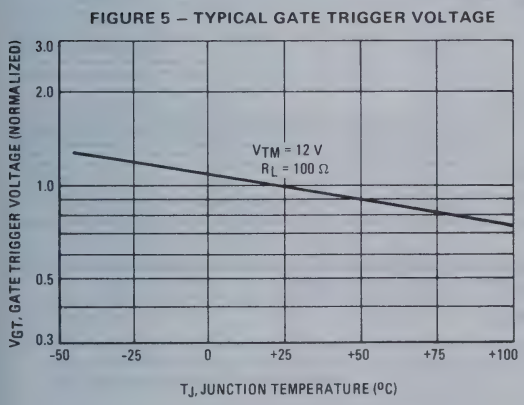


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

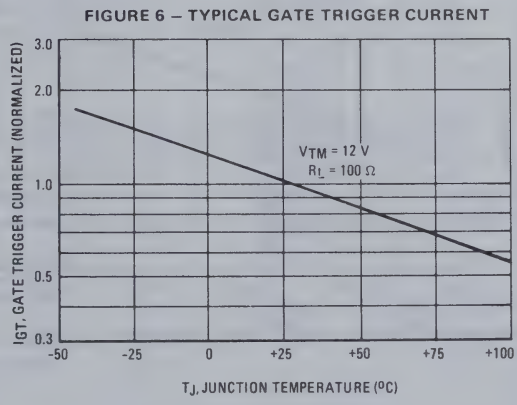


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

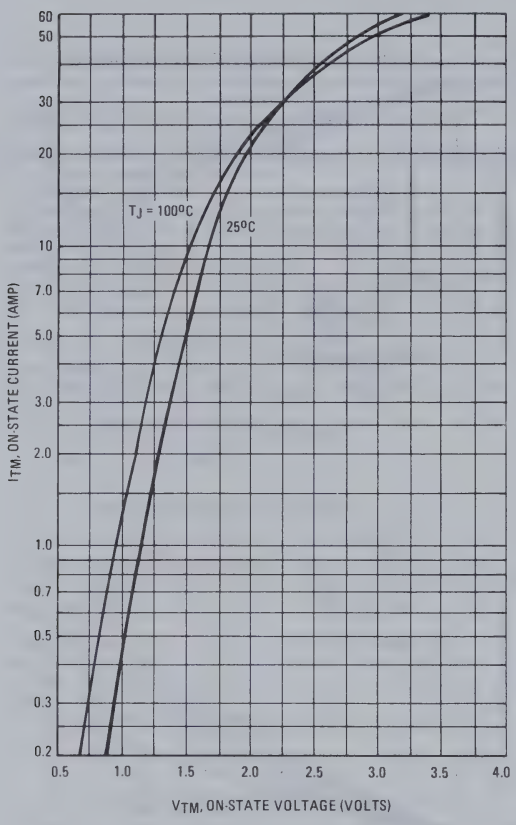


FIGURE 8 – TYPICAL HOLDING CURRENT

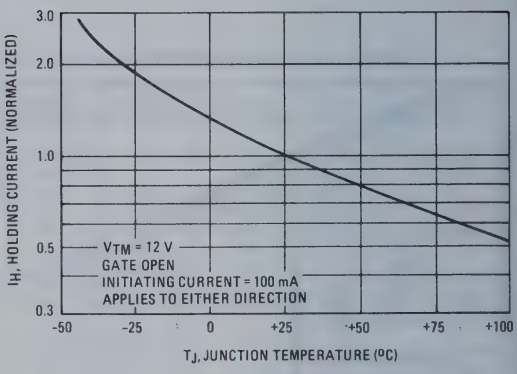


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

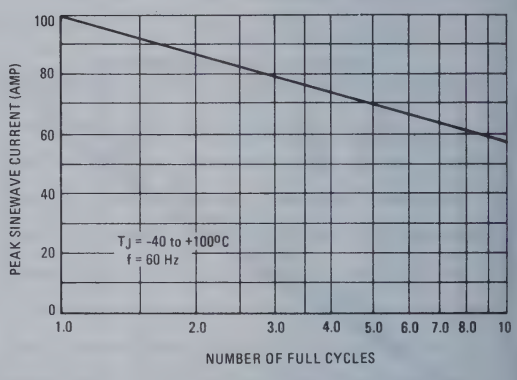
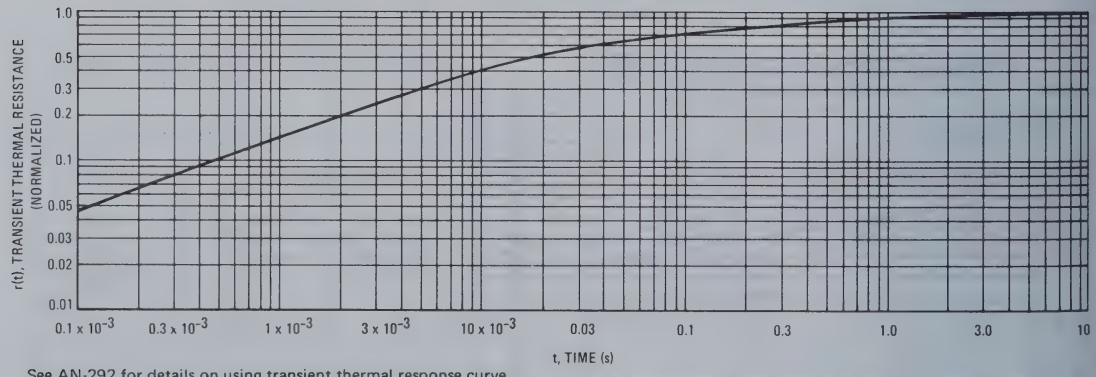


FIGURE 10 – THERMAL RESPONSE



See AN-292 for details on using transient thermal response curve.

MAC10-1 thru MAC10-8 (SILICON)
MAC11-1 thru MAC11-8



TRIACS
(THYRISTORS)

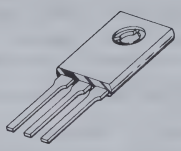
10 AMPERES RMS

25 THRU 600 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

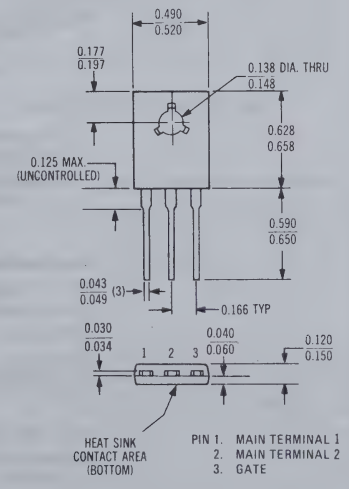
. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- All Diffused and Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Gate Triggering Guaranteed in Two (MAC11) or Four Modes (MAC10)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage, Note 1 (T_J = 100°C) –1	V_{DRM}	25	Volts
–2		50	
–3		100	
MAC10/11 –4		200	
–5		300	
–6		400	
–7		500	
–8		600	
On-State Current RMS (T_C = 75°C)	$I_{T(RMS)}$	10	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = –40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = –40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Peak Gate Power	P_{GM}	10	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	–40 to +100	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Mounting Torque (6-32 Screw), Note 2	—	8	in. lb.



CASE 90 (4)

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +200°C. For optimum results, an activated flux (oxide removing) is recommended.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
On-State Voltage (Either Direction) I_{TM} = 14 A Peak	V_{TM}	–	1.3	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms	I_{GT}				mA
MT2(+)G(+); MT2(–)G(–) MAC10, MAC11		–	–	50	
MT2(+)G(–); MT2(–)G(+) MAC10		–	–	75	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms	V_{GT}				Volts
MT2(+)G(+); MT2(–)G(–) MAC10, MAC11		–	0.9	2.0	
MT2(+)G(–); MT2(–)G(+) MAC10		–	1.0	2.5	
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 100°C	V_{GD}	0.2	–	–	Volts
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 100 mA	I_H	–	–	50	mA
Turn-On Time I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{on}	–	1.5	–	μs
Blocking Voltage Application Rate at Commutation @ V_{DRM}, T_J = 75°C, Gate Open	dv/dt	–	5.0	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	–	–	50	°C/W

MBS4991/MBS4992
Recommended for Triac Triggering

Triggers Provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

Electrical Characteristics

Symbol	MBS4991	MBS4992
V_S =	6–10 V	7.5–9.0 V
I_S =	350 μA Max	120 μA Max
$V_{S1}-V_{S2}$ =	0.5 V Max	0.2 V Max

Temperature Coefficient = 0.02%/°C Typ

(For light dimmer applications the MBS100 is recommended).

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

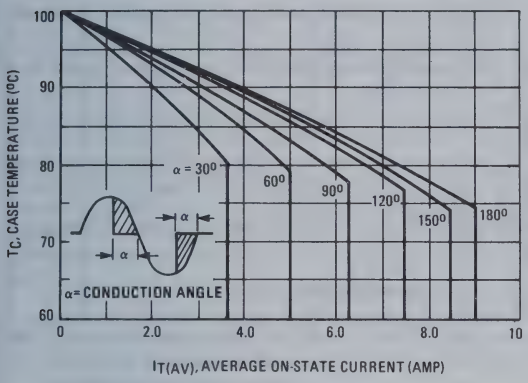


FIGURE 2 – RMS CURRENT DERATING

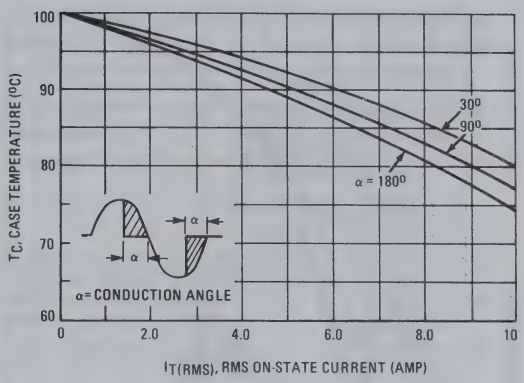


FIGURE 3 – POWER DISSIPATION

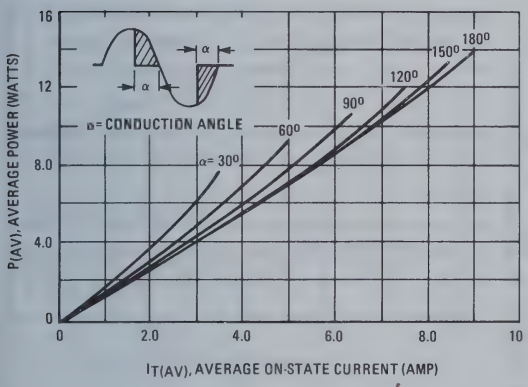


FIGURE 4 – POWER DISSIPATION

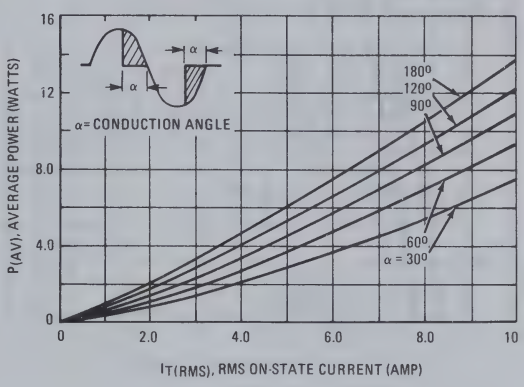


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

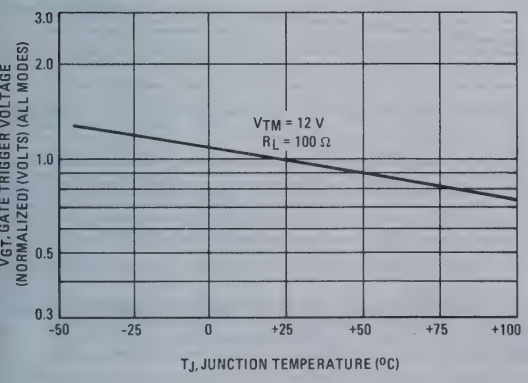


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

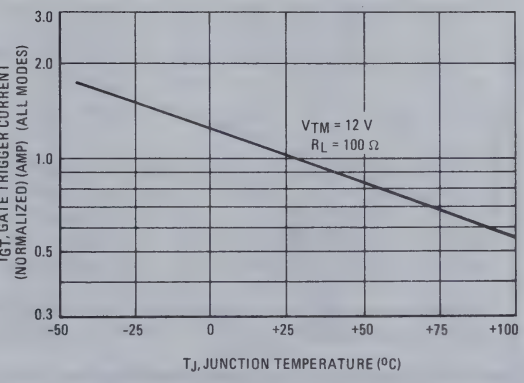


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

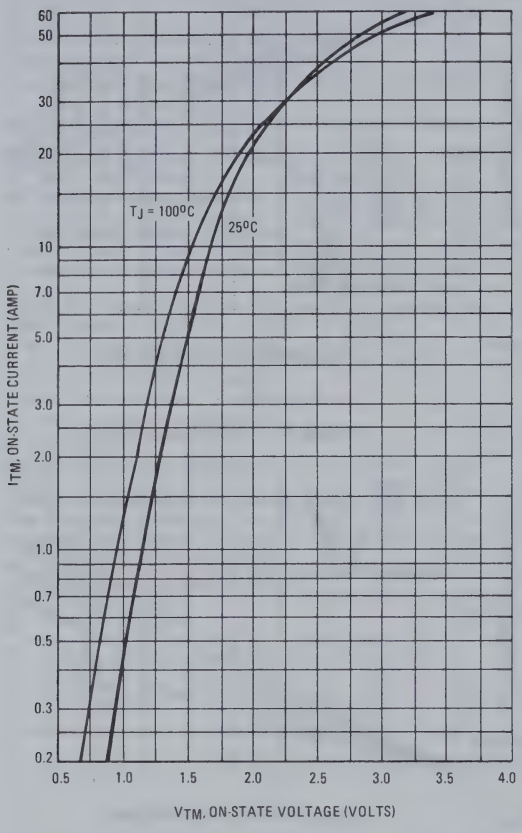


FIGURE 8 – TYPICAL HOLDING CURRENT

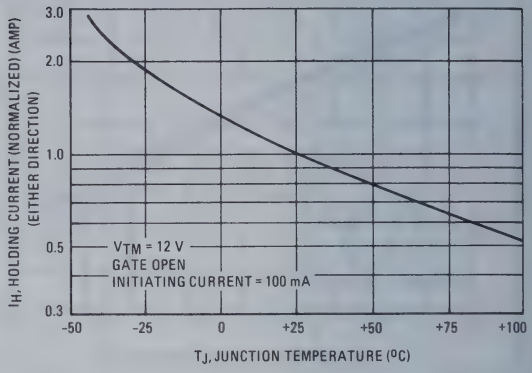


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

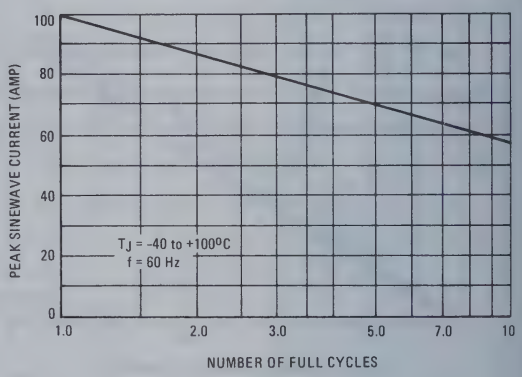
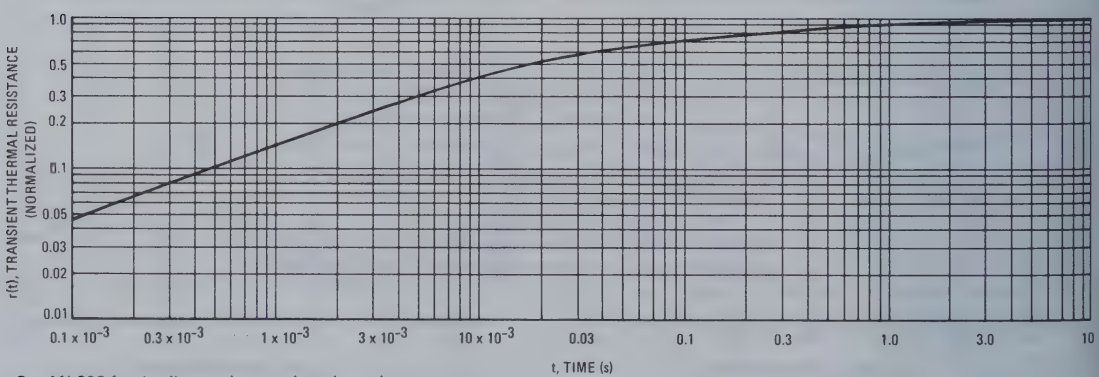


FIGURE 10 – THERMAL RESPONSE



See AN-292 for details on using transient thermal response curve.

MAC35-1 thru MAC35-7 (SILICON)
MAC36-1 thru MAC36-7



SILICON BIDIRECTIONAL THYRISTORS

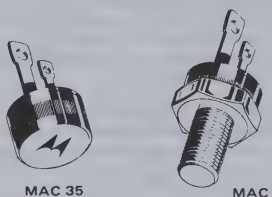
. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- 25 Amperes RMS @ T_C = 67°C
- Low On-State Voltage — 1.5 Volts Maximum
- All-Diffused Junctions for Greater Uniformity

TRIAC
(THYRISTORS)

25 AMPERES RMS
25 thru 500 VOLTS

JANUARY 1970 – DS 8533



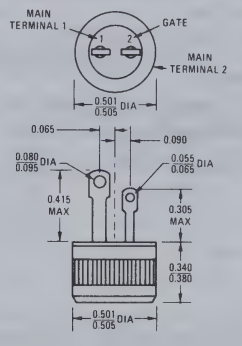
MAC 35 MAC 36

MAXIMUM RATINGS

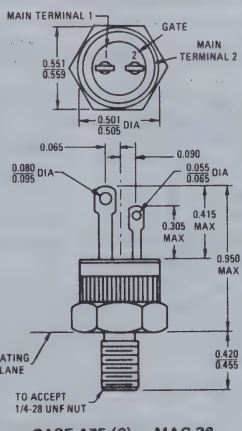
Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 110°C) MAC35 −1	V_{DRM}	25	Volts
MAC35 −2		50	
MAC35 −3		100	
MAC36 −4		200	
MAC36 −5		300	
MAC36 −6		400	
MAC36 −7		500	
On-State Current RMS	$I_{T(RMS)}$	25	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	225	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
Peak Gate Power (2)	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current (2)	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque	–	30	in. lb.

(1) For either direction of blocking voltage. V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) T_J = 110°C, 1.0 second maximum duration; 5.0% duty cycle, I_{TM} = 10 Amp.



CASE 174 (2) MAC 35



CASE 175 (2) MAC 36

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	–	4.0	mA
On-State Voltage (Either Direction) I_{TM} = 35 A Peak	V_{TM}	–	1.3	1.5	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	20	75	mA
MT2(+)G(–); MT2(–)G(+)	I_{GT}	–	30	100	mA
Gate Trigger Voltage, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	3.0	Volts
MT2(+) G(–); MT2(–)G(+)	V_{GT}	–	1.2	3.0	Volts
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C	V_{GD}	0.2	–	–	Volt
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 150 mA	I_H	–	10	75	mA
Turn-On Time I_{TM} = 25 Adc, I_{GT} = 200 mA	t_{on}	–	1.0	–	μs
Critical Forward Voltage Application Rate (Exponential Rise of Voltage) @ V_{DRM}, T_J = 110°C, Gate Open	dv/dt	–	100	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	1.0	°C/W

(1) All voltage polarity reference to main terminal 1.

FIGURE 1 – MAXIMUM THERMAL RESPONSE

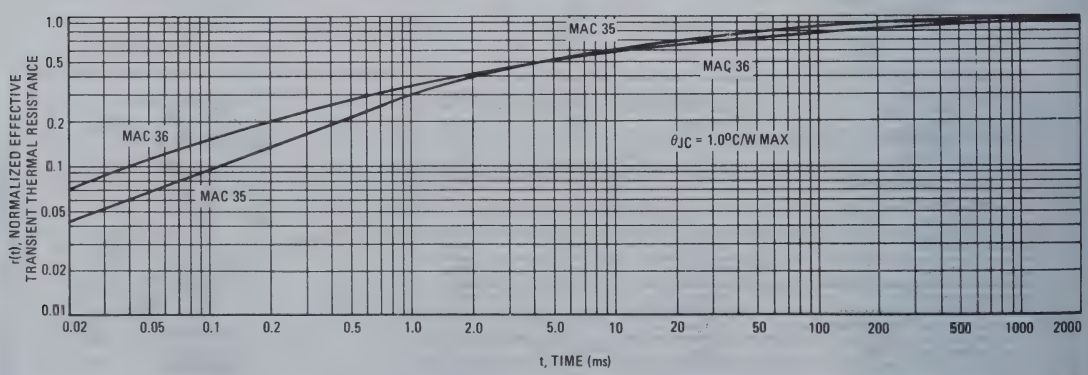


FIGURE 2 – AVERAGE CURRENT DERATING

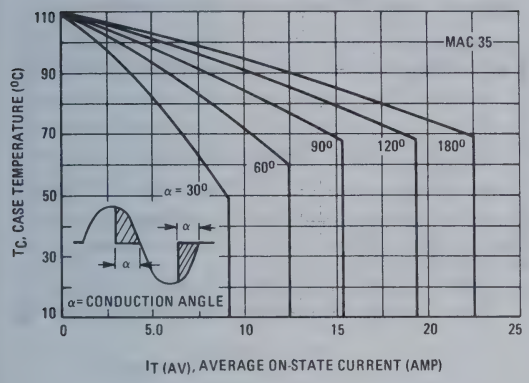


FIGURE 3 – RMS CURRENT DERATING

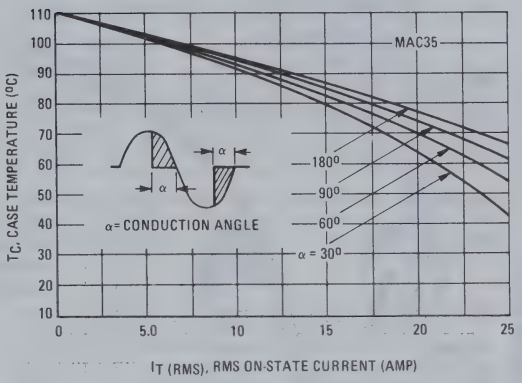


FIGURE 4 – AVERAGE CURRENT DERATING

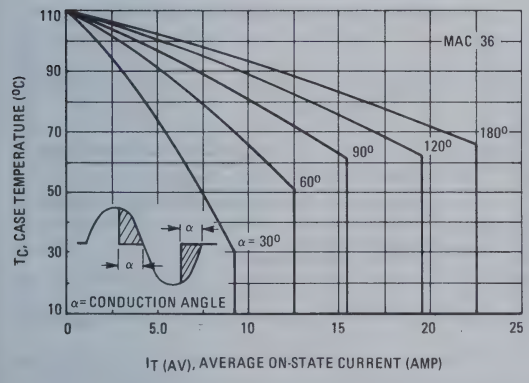


FIGURE 5 – RMS CURRENT DERATING

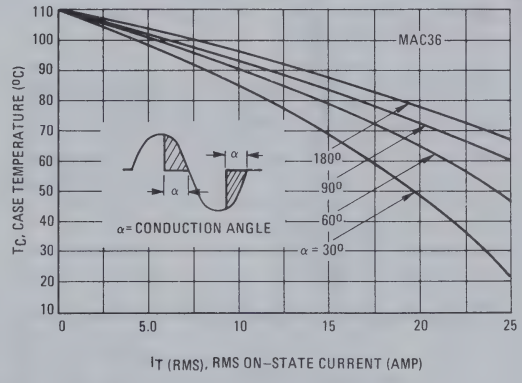


FIGURE 6 – POWER DISSIPATION versus AVERAGE CURRENT

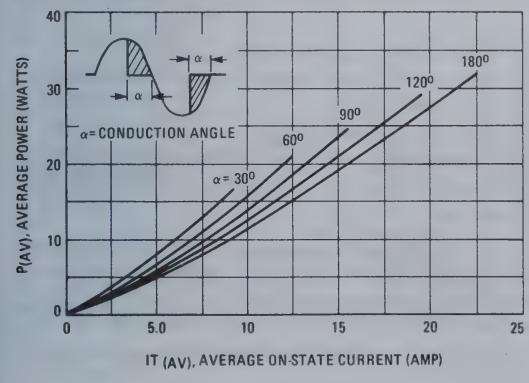


FIGURE 7 – POWER DISSIPATION versus RMS CURRENT

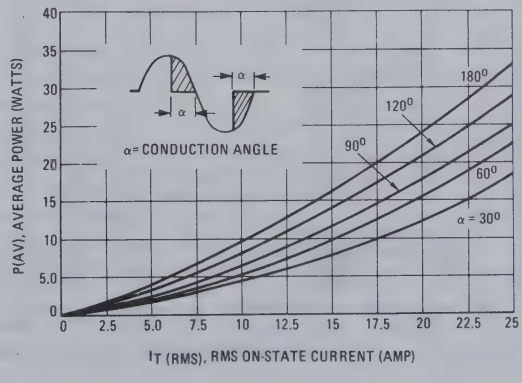


FIGURE 8 – MAXIMUM ON-STATE CHARACTERISTICS

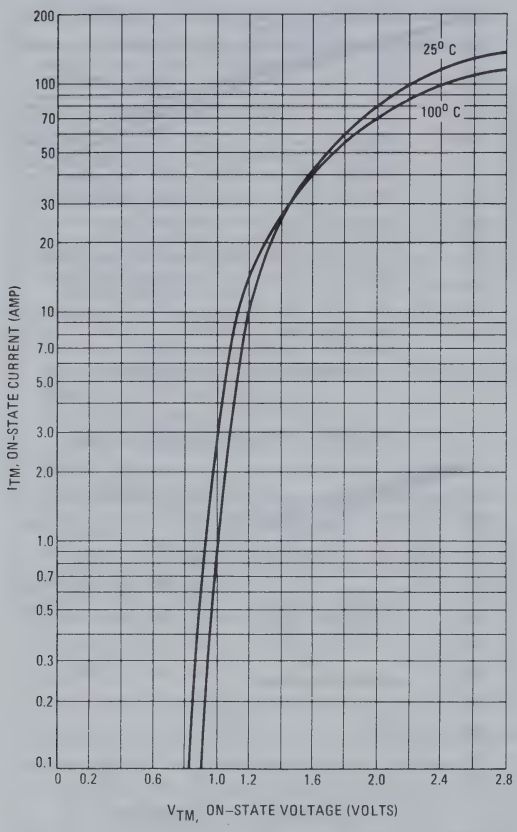


FIGURE 9 – MAXIMUM MULTI-CYCLE SURGE RATING

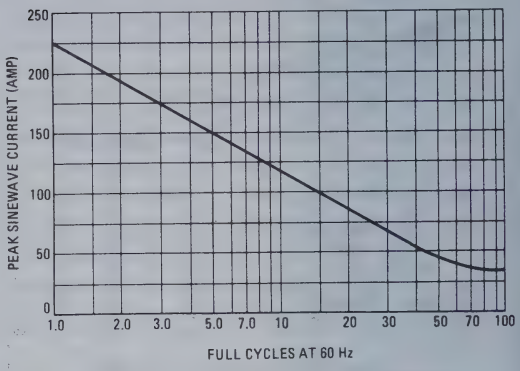


FIGURE 10 – TYPICAL HOLDING CURRENT

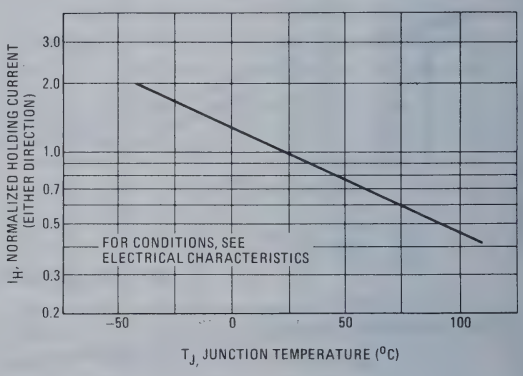


FIGURE 11 – TYPICAL GATE TRIGGER CURRENT

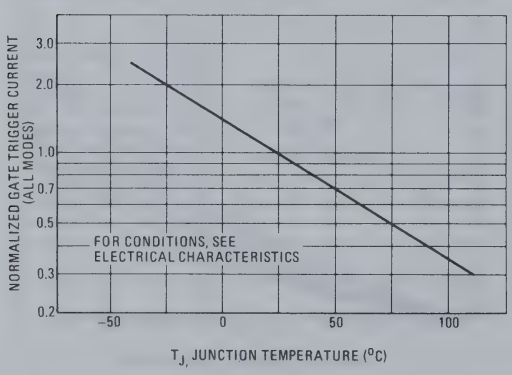
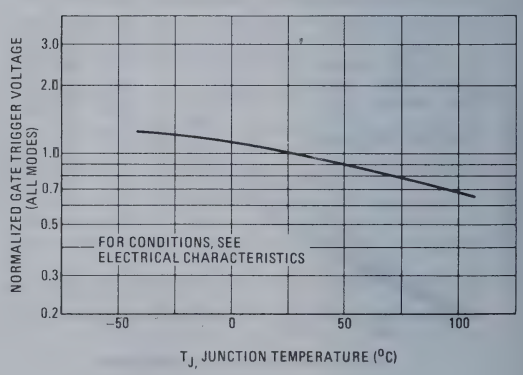


FIGURE 12 – TYPICAL GATE TRIGGER VOLTAGE



MAC37-1 thru MAC37-7 (SILICON)
MAC38-1 thru MAC38-7



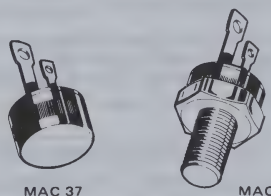
TRIAC
(THYRISTORS)

25 AMPERES RMS
25 thru 500 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- 25 Amperes RMS @ T_C = 67°C
- Low On-State Voltage — 1.5 Volts Maximum
- All-Diffused Junctions for Greater Uniformity
- Gate Triggering Guaranteed in Two Modes



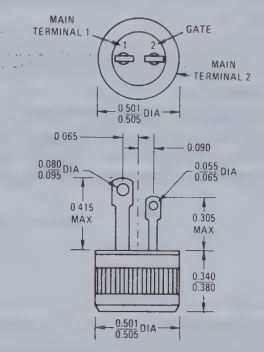
MAC 37 MAC 38

MAXIMUM RATINGS

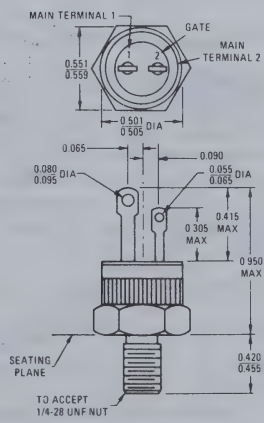
Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 110°C) MAC37 −1	V_{DRM}	25	Volts
MAC37 −2		50	
MAC37 −3		100	
MAC38 −4		200	
MAC38 −5		300	
MAC38 −6		400	
MAC38 −7		500	
On-State Current RMS	$I_{T(RMS)}$	25	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	225	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
Peak Gate Power (2)	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current (2)	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque	–	30	in. lb.

(1) For either direction of blocking voltage. V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) T_J = 110°C, 1.0 second maximum duration; 5.0% duty cycle, I_{TM} = 10 Amp.



CASE 174(3) MAC 37



CASE 175(3) MAC 38

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	–	4.0	mA
On-State Voltage (Either Direction) I_{TM} = 35 A Peak	V_{TM}	–	1.3	1.9	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	20	75	mA mA
Gate Trigger Voltage, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	3.0	Volts
Gate Trigger Voltage, Continuous dc – MT2(+) G(+); MT2(–) G(–) Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C	V_{GD}	0.2	–	–	Volt
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 150 mA	I_H	–	10	75	mA
Turn-On Time I_{TM} = 25 Adc, I_{GT} = 200 mA	t_{on}	–	1.0	–	μs
Critical Forward Voltage Application Rate (Exponential Rise of Voltage) @ V_{DRM}, T_J = 110°C, Gate Open	dv/dt	–	100	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	1.0	°C/W

(1) All voltage polarity reference to main terminal 1.

FIGURE 1 – MAXIMUM THERMAL RESPONSE

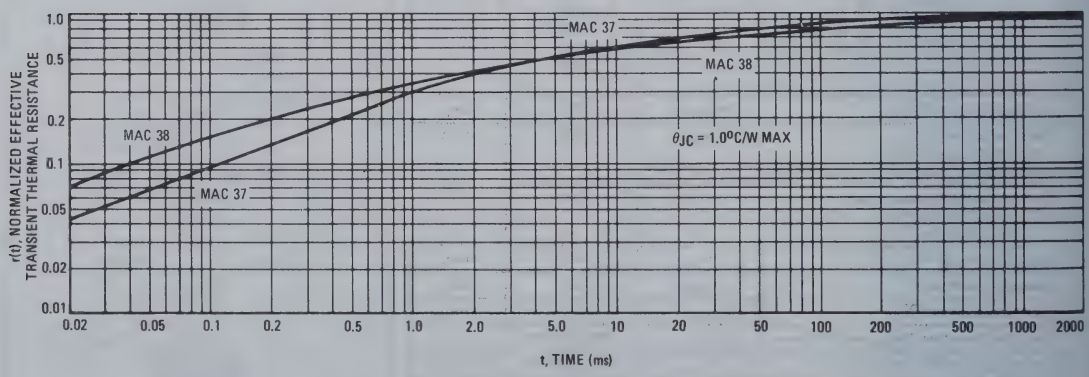


FIGURE 2 – AVERAGE CURRENT DERATING

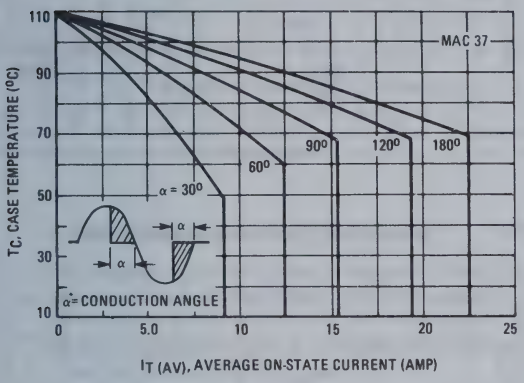


FIGURE 3 – RMS CURRENT DERATING

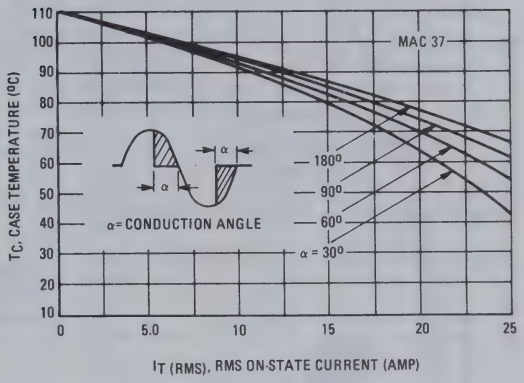


FIGURE 4 – AVERAGE CURRENT DERATING

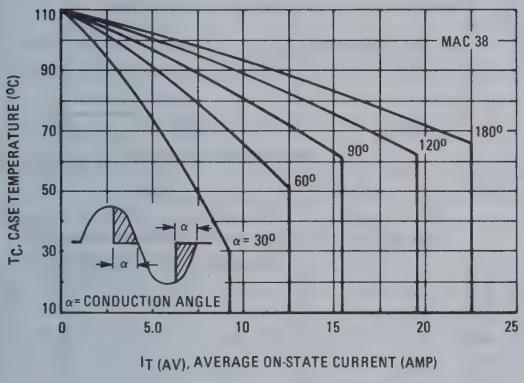


FIGURE 5 – RMS CURRENT DERATING

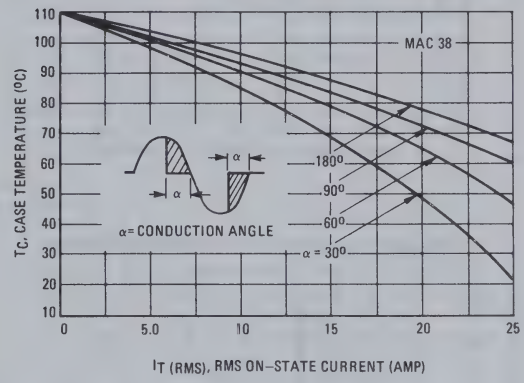


FIGURE 6 – POWER DISSIPATION versus AVERAGE CURRENT

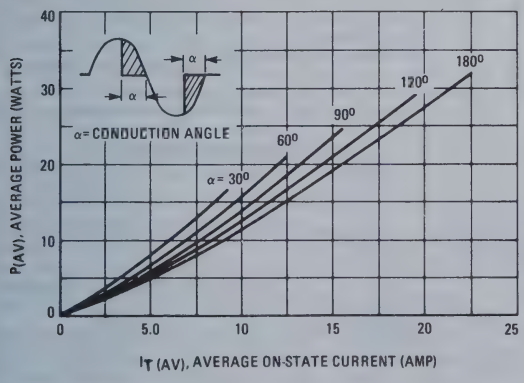


FIGURE 7 – POWER DISSIPATION versus RMS CURRENT

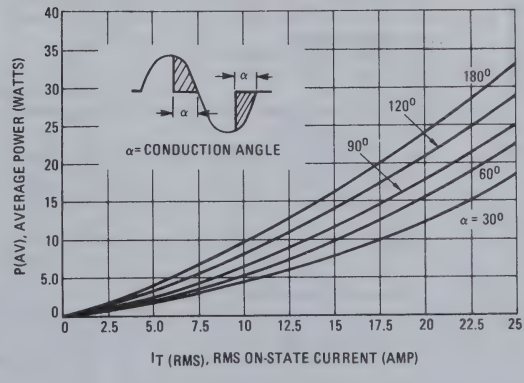


FIGURE 8 – MAXIMUM ON-STATE CHARACTERISTICS

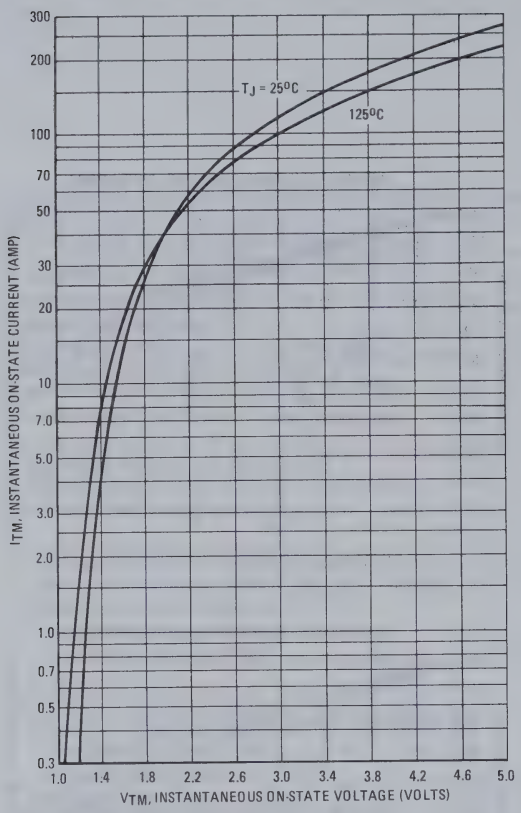


FIGURE 9 – MAXIMUM MULTI-CYCLE SURGE RATING

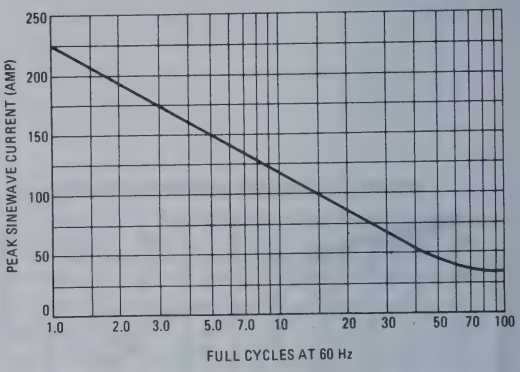


FIGURE 10 – TYPICAL HOLDING CURRENT

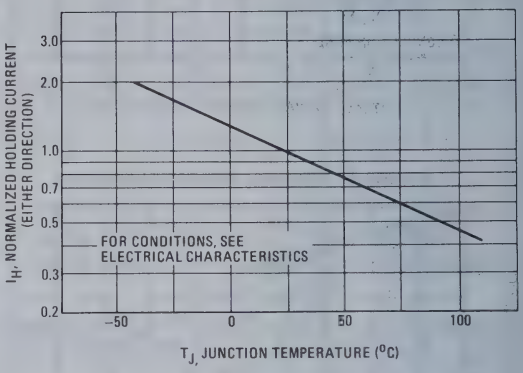


FIGURE 11 – TYPICAL GATE TRIGGER CURRENT

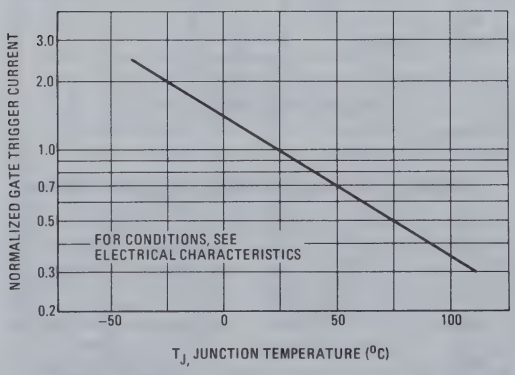
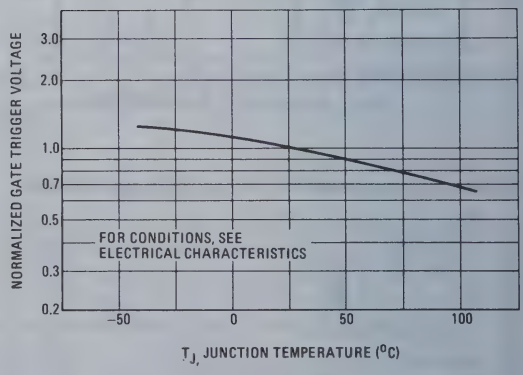


FIGURE 12 – TYPICAL GATE TRIGGER VOLTAGE



MAC92-1 thru MAC92-6 (SILICON)
MAC92A-1 thru MAC92A-6



TRIACS
(THYRISTORS)

0.45 AMPERE RMS
30-400 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC92 Series) or Four Modes (MAC92A Series)
- One-Piece, Injection-Molded Unibloc Package

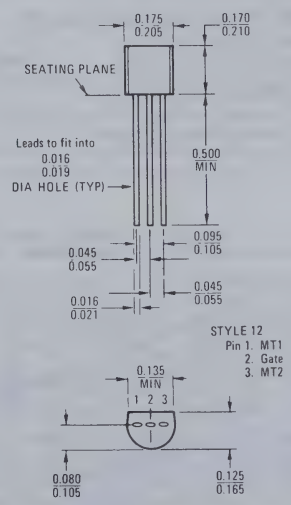


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = -40 to +100°C) ½ Sine Wave 50 to 60 Hz, Gate Open	V_{DRM}		Volts
MAC92 and MAC92A – 1		30	
– 2		60	
– 3		100	
– 4		200	
– 5		300	
– 6		400	
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.45	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.1	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W



All JEDEC dimensions and notes apply

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	100	μA
Peak On-State Voltage (Either Direction) I_{TM} = 0.7 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0%	V_{TM}	–	1.7	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms	I_{GT}			mA
MT2 (+), G(+); MT2(–), G(–) All Devices		–	5.0	
MT2(+), G(–); MT2(–), G(+) MAC92A-1 thru MAC92A-6		–	15	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GT}			Volts
MT2 (+), G(+); MT2(–), G(–) All Devices		–	2.0	
MT2(+), G(–); MT2(–), G(+) MAC92A-1 thru MAC92A-6		–	2.0	
MT2 (+), G(+); MT2(–), G(–), T_C = –40°C All Devices		–	3.0	
MT2(+), G(–); MT2(–), G(+) T_C = –40°C MAC92A-1 thru MAC92A-6		–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C				
MT2 (+), G(+); MT2(–), G(–) All Devices		0.1	–	
MT2(+), G(–); MT2(–), G(+) MAC92A-1 thru MAC92A-6		0.1	–	
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open; T_C = 25°C Initiating Current = 20 mA T_C = –40°C	I_H	– –	10 20	mA

FIGURE 1 – TYPICAL GATE TRIGGER VOLTAGE

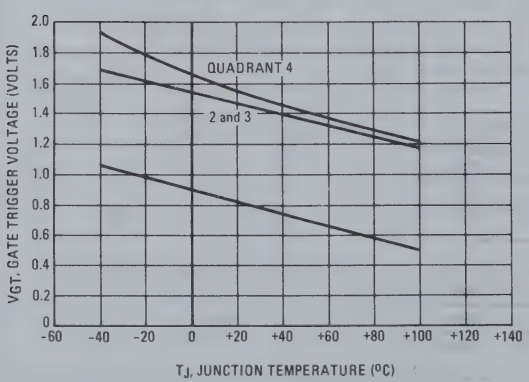


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

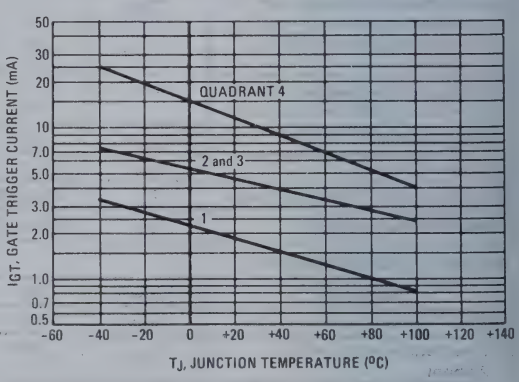


FIGURE 3 – AVERAGE CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

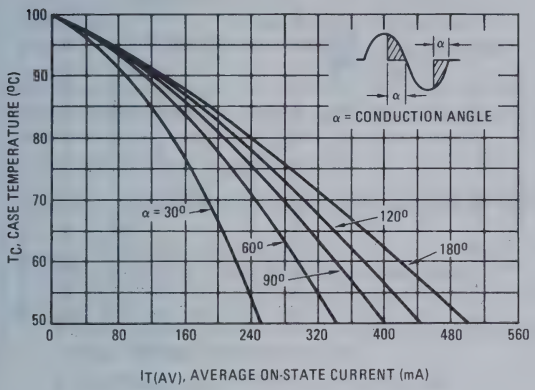


FIGURE 4 – RMS CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

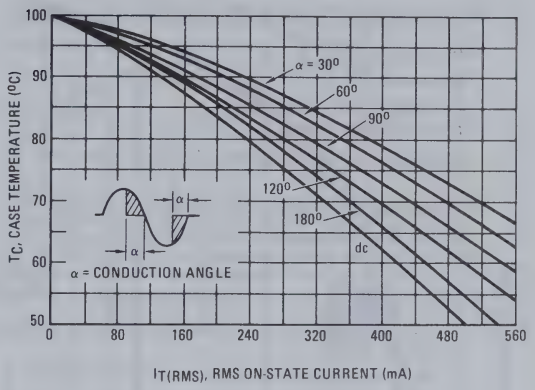


FIGURE 5 – AVERAGE CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

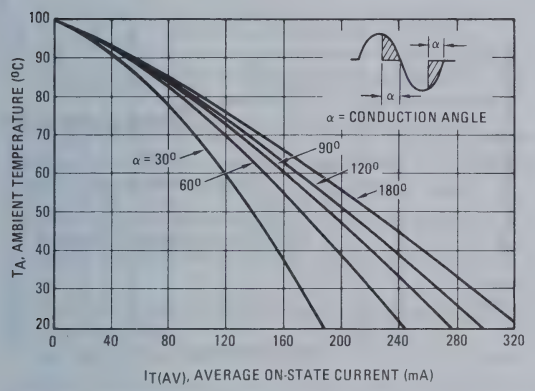


FIGURE 6 – RMS CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

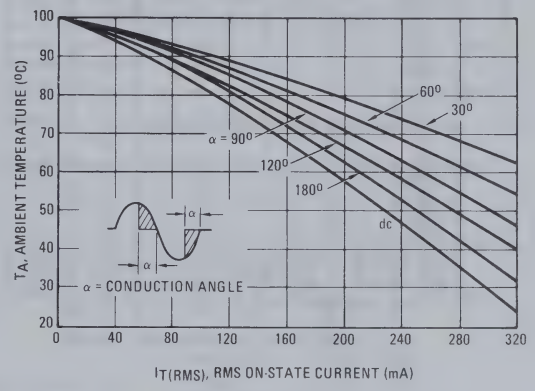


FIGURE 7 – ON-STATE POWER DISSIPATION

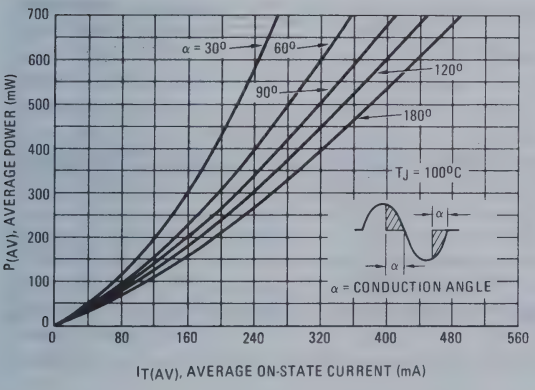


FIGURE 8 – ON-STATE POWER DISSIPATION

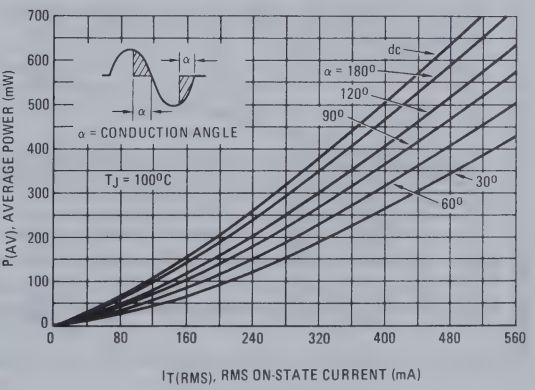


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

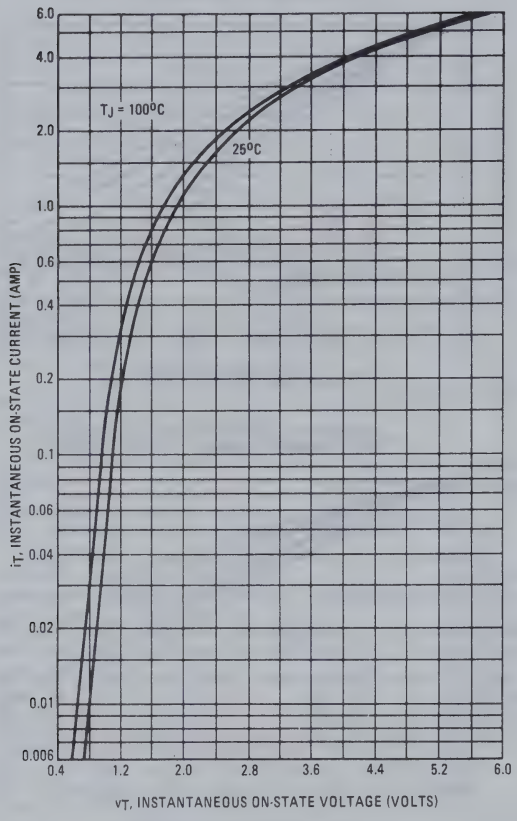


FIGURE 10 – TYPICAL HOLDING CURRENT

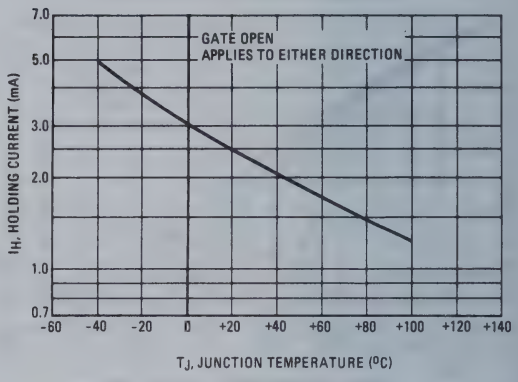


FIGURE 11 – MAXIMUM ALLOWABLE SURGE CURRENT

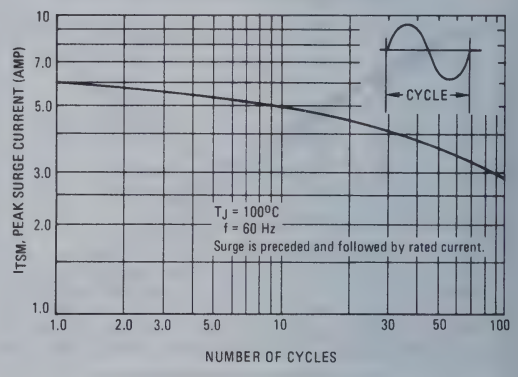
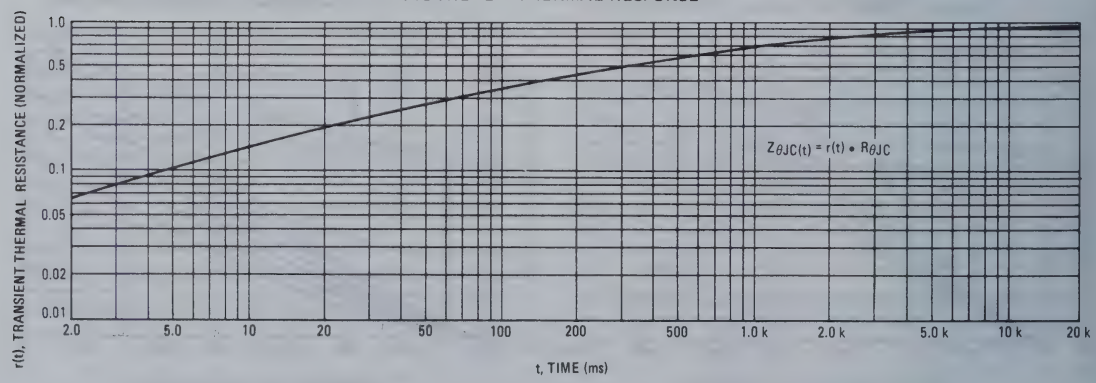


FIGURE 12 – THERMAL RESPONSE



MAC93-1 thru MAC93-4 (SILICON)
MAC93A-1 thru MAC93A-4



TRIACS
(THYRISTORS)

0.65 AMPERE RMS
30-200 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

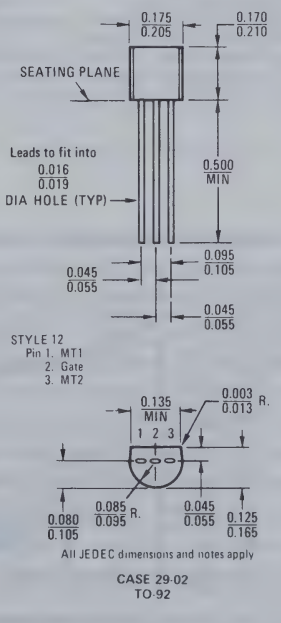
. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC93 Series) or Four Modes (MAC93A Series)
- One-Piece, Injection-Molded Unibloc Package



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = -40 to +125°C) ½ Sine Wave 50 to 60 Hz, Gate Open MAC93 and MAC93A — 1 2 3 4	V_{DRM}	 30 60 100 200	Volts
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.65	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.1	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C



THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 125°C, Gate Open	I_{DRM}	–	100	μA
Peak On-State Voltage (Either Direction) I_{TM} = 0.92 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0%	V_{TM}	–	1.85	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GT}			mA
MT2 (+), G(+); MT2(–), G(–) All Devices		–	5.0	
MT2(+), G(–); MT2(–), G(+) MAC93A-1 thru MAC93A-4		–	12	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GT}			Volts
MT2 (+), G(+); MT2(–), G(–) All Devices		–	2.0	
MT2(+), G(–); MT2(–), G(+) MAC93A-1 thru MAC93A-4		–	2.0	
MT2 (+), G(+); MT2(–), G(–) T_C = –40°C All Devices		–	2.5	
MT2(+), G(–); MT2(–), G(+) T_C = –40°C MAC93A-4		–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C				
MT2 (+), G(+); MT2(–), G(–) All Devices		0.1	–	
MT2(+), G(+); MT2(–), G(–) MAC93A-1 thru MAC93A-4		0.1	–	
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 20 mA T_C = 25°C	I_H	–	10	mA
T_C = –40°C		–	20	

FIGURE 1 – TYPICAL GATE TRIGGER VOLTAGE

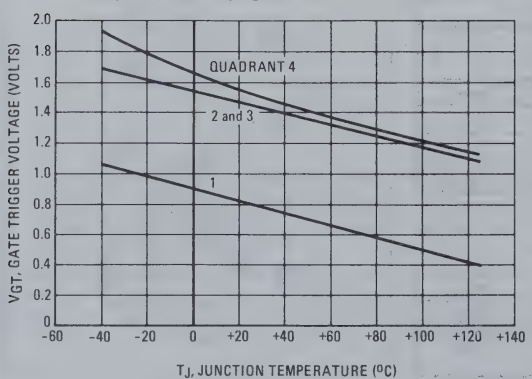


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

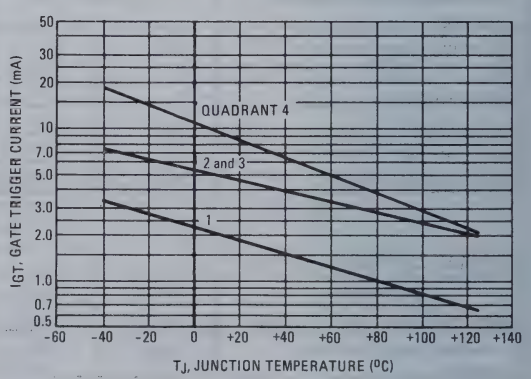


FIGURE 3 – AVERAGE CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

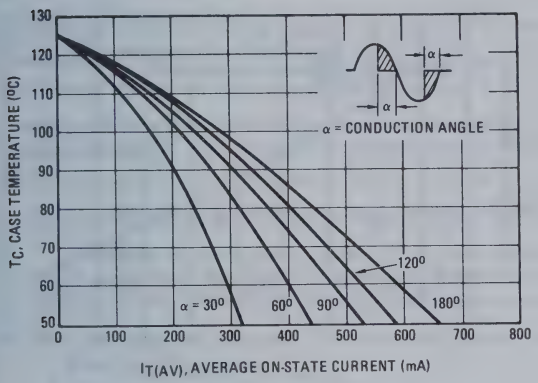


FIGURE 4 – RMS CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

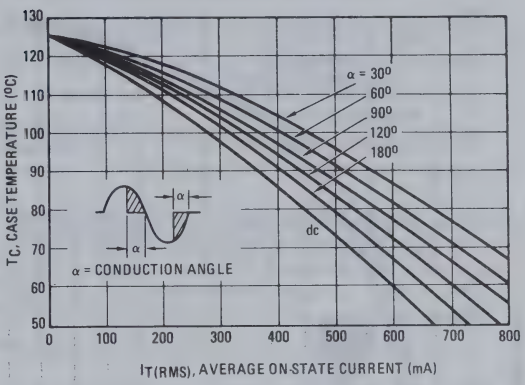


FIGURE 5 – AVERAGE CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

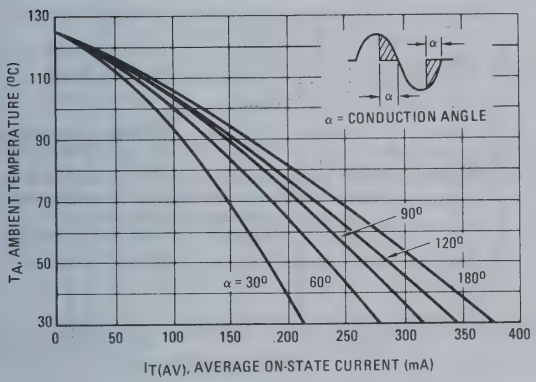


FIGURE 6 – RMS CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

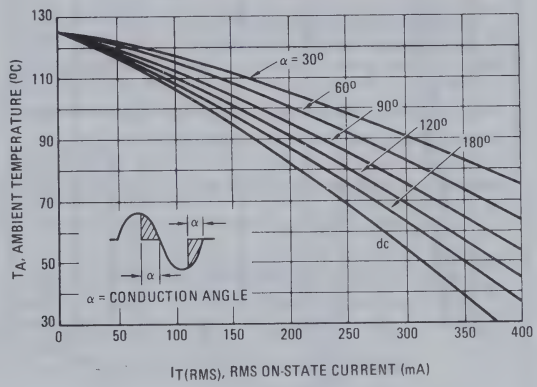


FIGURE 7 – ON-STATE POWER DISSIPATION

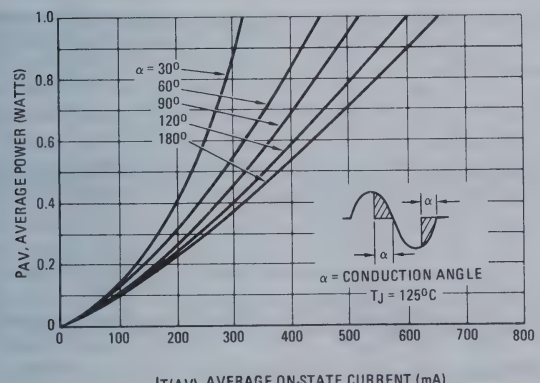


FIGURE 8 – ON-STATE POWER DISSIPATION

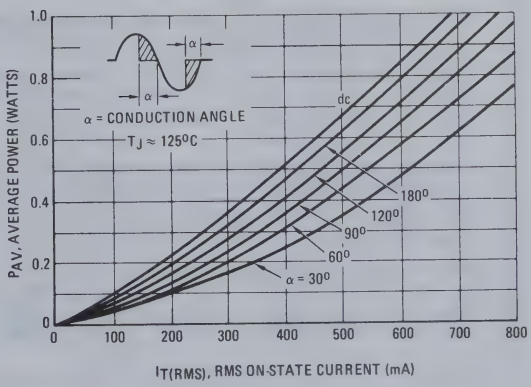


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

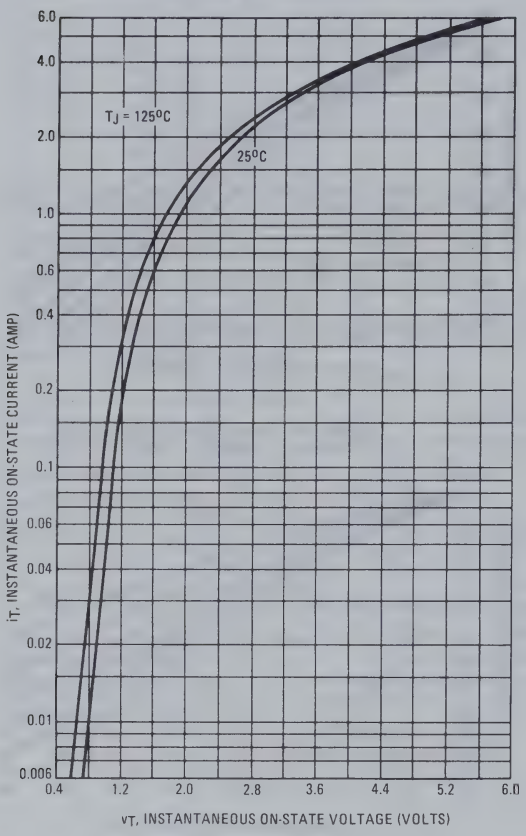


FIGURE 10 – TYPICAL HOLDING CURRENT

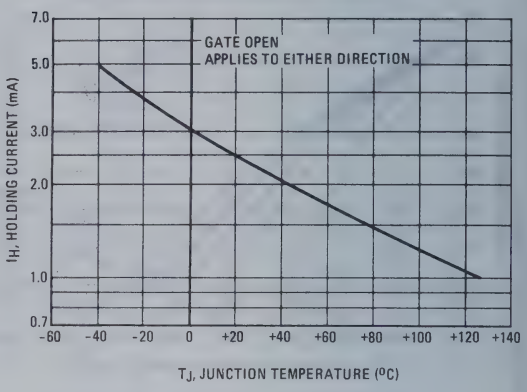


FIGURE 11 – MAXIMUM NON-REPETITIVE SURGE CURRENT

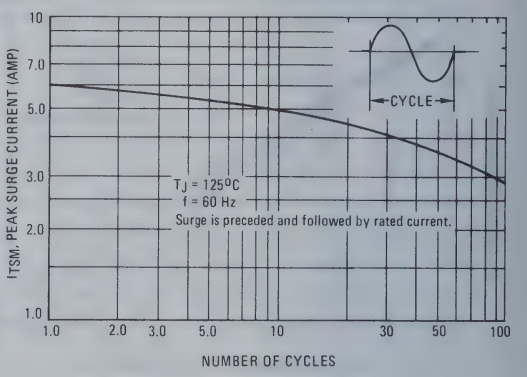
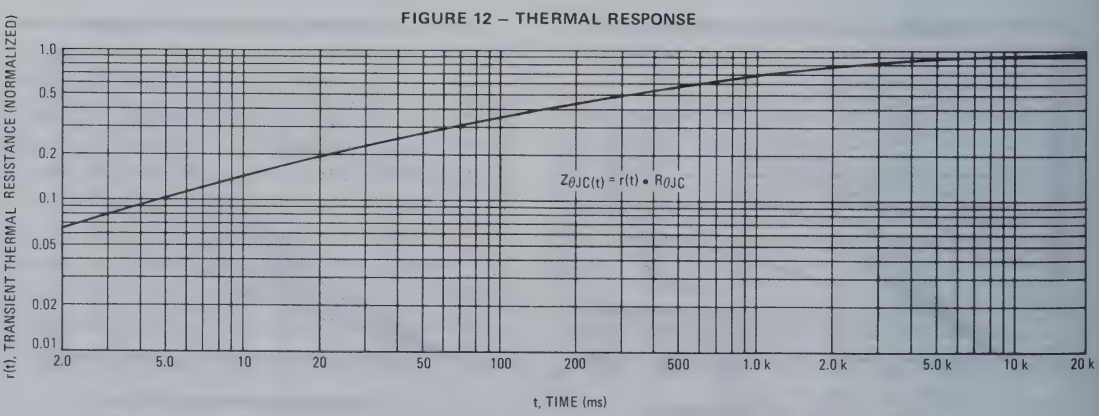


FIGURE 12 – THERMAL RESPONSE



MAC94-1 thru MAC94-4 (SILICON)
MAC94A-1 thru MAC94A-4



TRIACS
(THYRISTORS)
0.8 AMPERE RMS
30–200 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

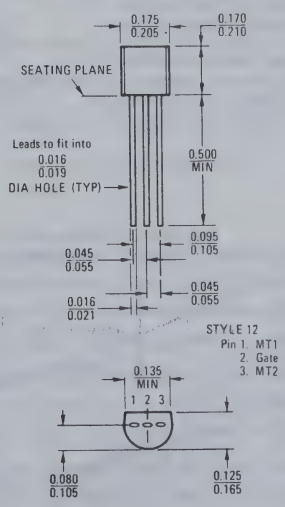
. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC94 Series) or Four Modes (MAC94A Series)
- One-Piece, Injection-Molded Unibloc Package



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = -40 to +125°C) ½ Sine Wave 50 to 60 Hz, Gate Open MAC94 and MAC94A – 1 2 3 4	V_{DRM}	 30 60 100 200	Volts
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.8	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.1	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C



All JEDEC dimensions and notes apply

CASE 29-02
TO-92

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 125°C, Gate Open	I_{DRM}	–	2.0	mA
Peak On-State Voltage (Either Direction) I_{TM} = 1.12A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ≤ 2.0%	V_{TM}	–	1.5	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GT}			mA
MT2 (+), G(+); MT2(–), G(–) All Devices		–	5.0	
MT2(+), G(–); MT2(–), G(+) MAC94A-1 thru MAC94A-4		–	10	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GT}			Volts
MT2 (+), G(+); MT2(–), G(–) All Devices		–	2.0	
MT2(+), G(–); MT2(–), G(+) MAC94A-1 thru MAC94A-4		–	2.0	
MT2 (+), G(+); MT2(–), G(–) T_C = -40°C All Devices		–	3.0	
MT2(+), G(–); MT2(–), G(+) T_C = -40°C MAC94A-1 thru MAC94A-4		–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C				
MT2 (+), G(+); MT2(–), G(–) All Devices		0.1	–	
MT2(+), G(–); MT2(–), G(+) MAC94A-1 thru MAC94A-4		0.1	–	
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 20 mA T_C = 25°C	I_H	–	10	mA
T_C = -40°C		–	20	

FIGURE 1 – TYPICAL GATE TRIGGER VOLTAGE

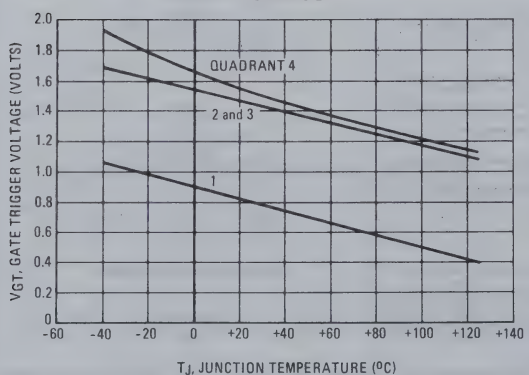


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

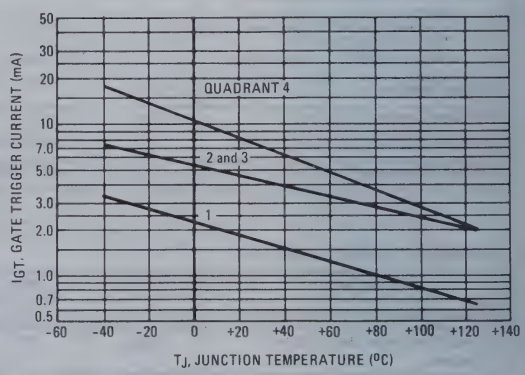


FIGURE 3 – AVERAGE CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

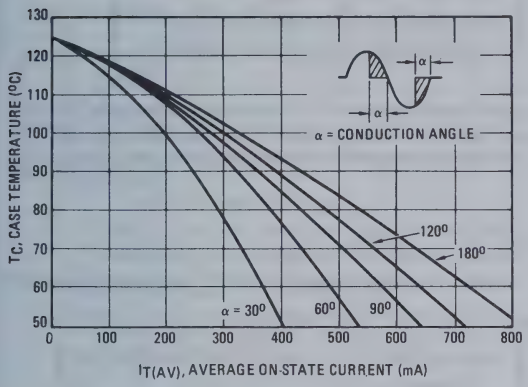


FIGURE 4 – RMS CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

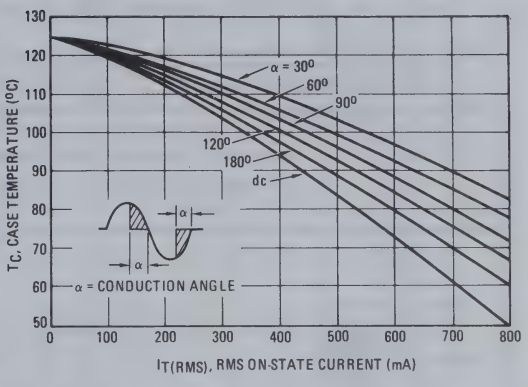


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE)

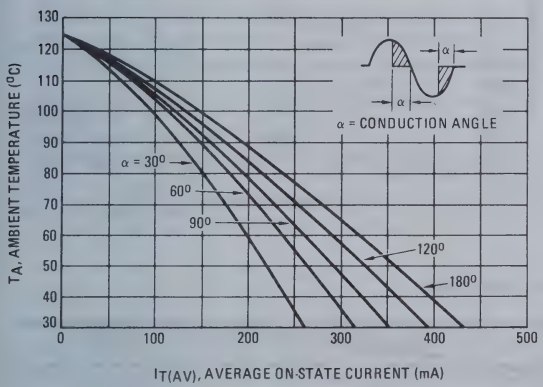


FIGURE 6 – RMS CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE)

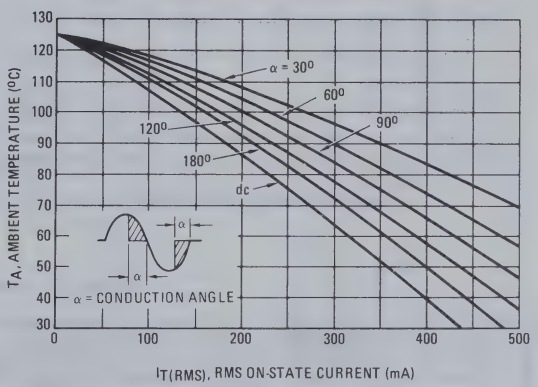


FIGURE 7 – ON-STATE POWER DISSIPATION

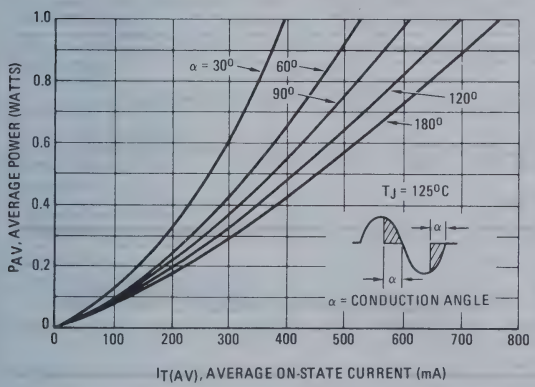


FIGURE 8 – ON-STATE POWER DISSIPATION

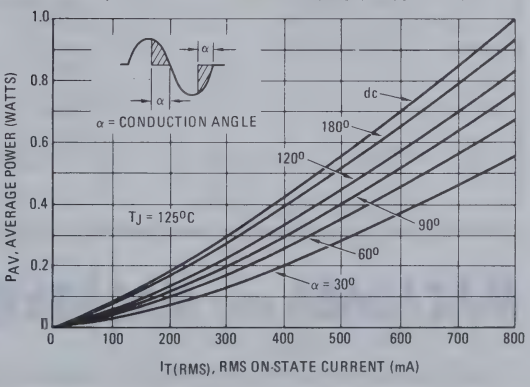


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

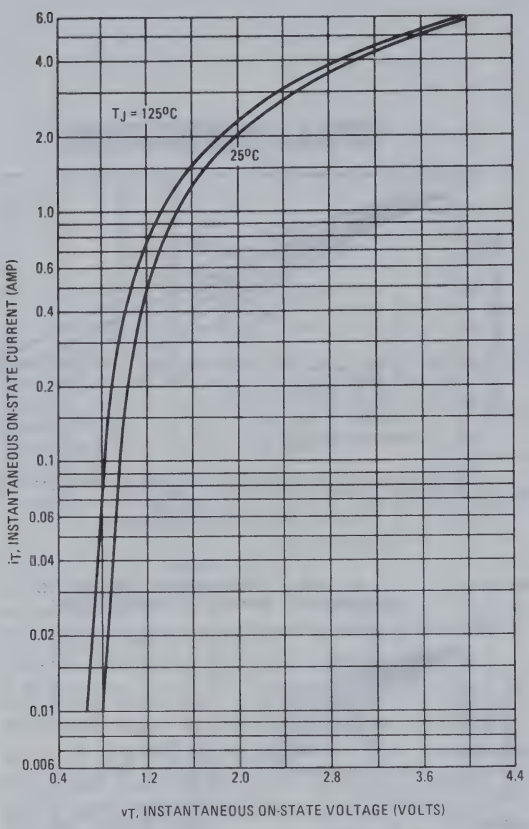


FIGURE 10 – TYPICAL HOLDING CURRENT

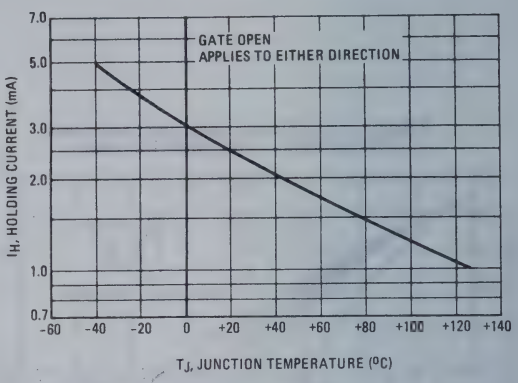


FIGURE 11 – MAXIMUM NON-REPETITIVE SURGE CURRENT

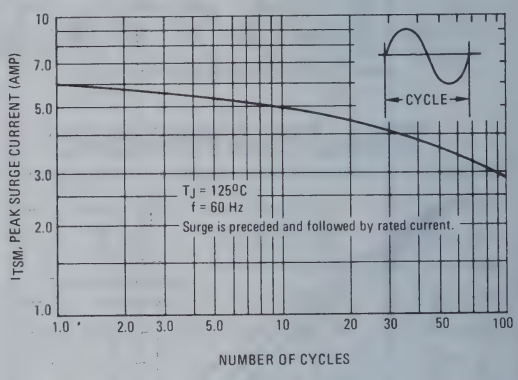
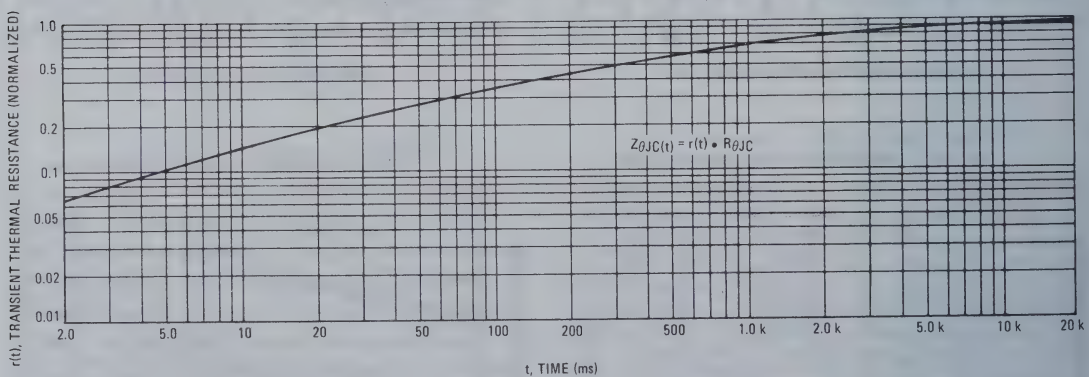


FIGURE 12 – THERMAL RESPONSE



MAC40688 thru MAC40690

For Specifications, See 2N5441 Data.

MAC40797, MAC40798

For Specifications, See 2N5571 Data.

MBD101 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure – 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance – Less Than 1.0 pF @ Zero Volts
- High Forward Conductance – 0.48 Volts (Typ) @ I_F = 10 mA

SILICON HOT-CARRIER UHF MIXER DIODE



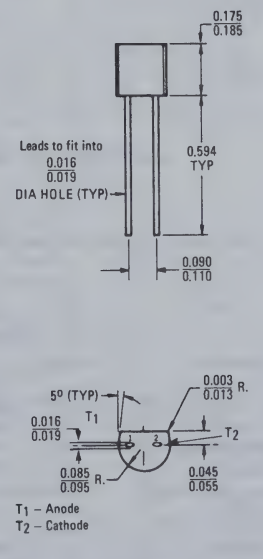
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F (1)	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.



CASE 182-1

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

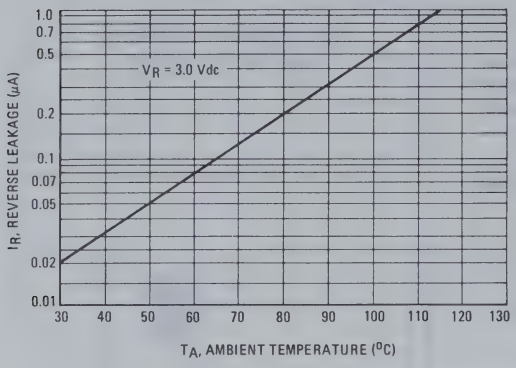


FIGURE 2 – FORWARD VOLTAGE

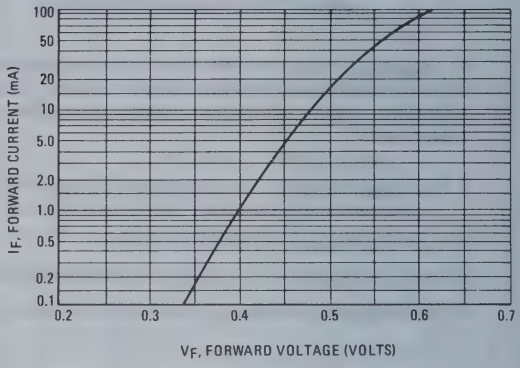


FIGURE 3 – CAPACITANCE

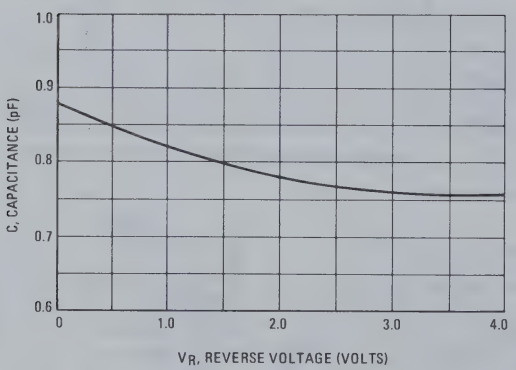


FIGURE 4 – NOISE FIGURE

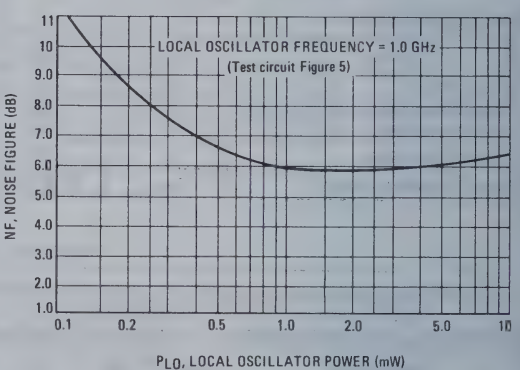
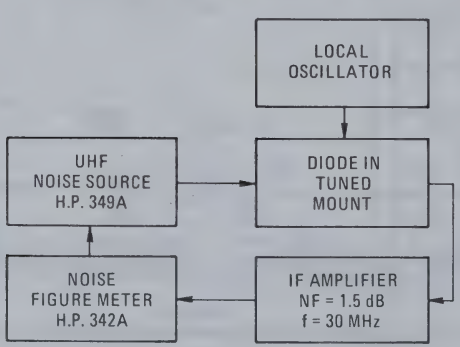


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

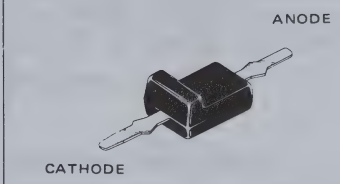
MBD102 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in the low-inductance Mini-L package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 5.5 dB Typical @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.48 volts (Typ) @ I_F = 10 mA
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

SILICON HOT-CARRIER UHF MIXER DIODE



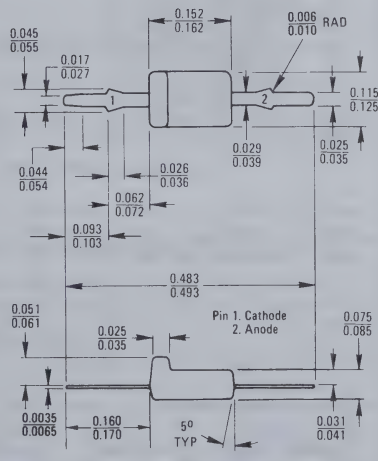
MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.8	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F(1)	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Measured at Lead Stop ≈ 1/8")	L_S	-	3.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz)	C_C	–	0.1	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.



To convert inches to millimeters multiply by 25.4

CASE 226

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

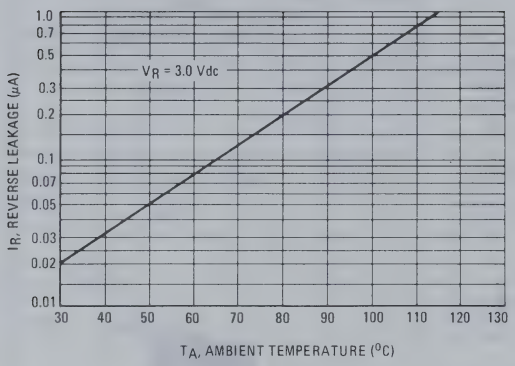


FIGURE 2 – FORWARD VOLTAGE

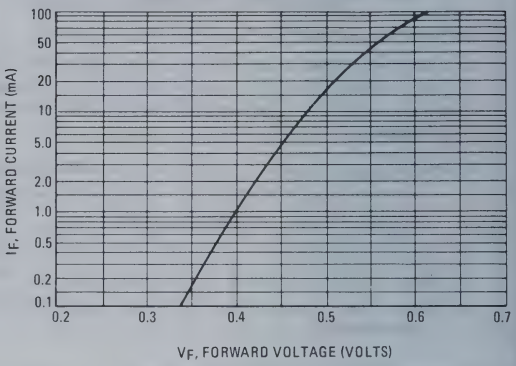


FIGURE 3 – DIODE CAPACITANCE

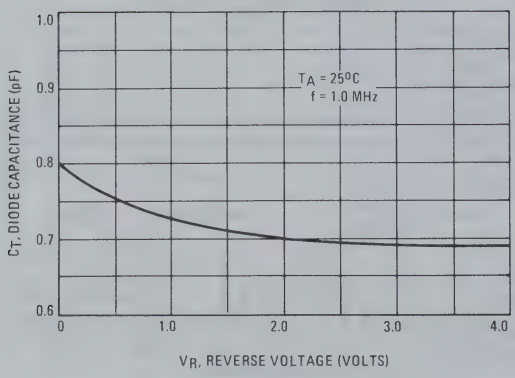


FIGURE 4 – NOISE FIGURE

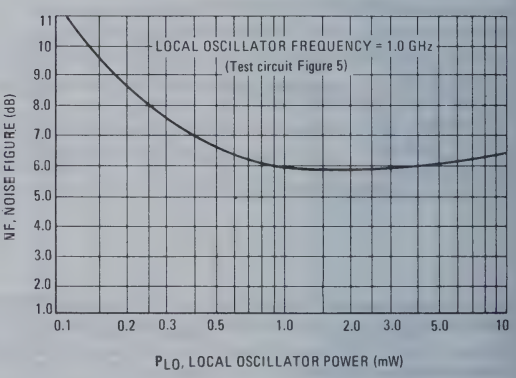
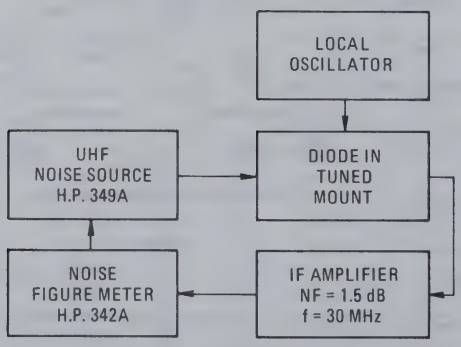


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD501 (SILICON)
MBD701

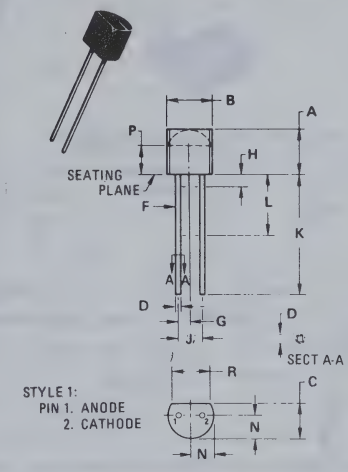


SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commerical requirements.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics By Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 100 ps (Max)
- Very Low Capacitance — 1.0 pF
- High Reverse Voltage — to 70 Volts
- Low Reverse Leakage — 200 nA (Max)

HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES
50-70 VOLTS



CASE 182-1

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

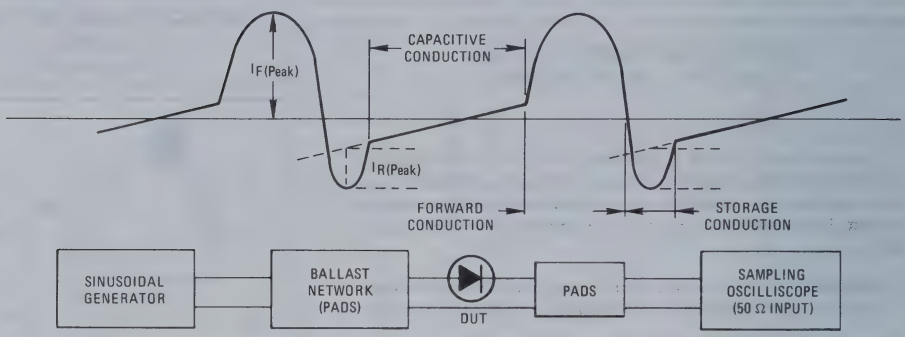
MAXIMUM RATING (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage MBD501 MBD701	V_R	 50 70	Volts
Forward Power Dissipation @ T_A = 25°C Derate Above 25°C	P_F	500 5.0	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	 MBD501 MBD701	$V_{(BR)R}$	 50 70	 – –	 – –	Volts
Total Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)		C_T	–	0.5	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)		τ	–	15	100	ps
Reverse Leakage, Figure 3 (V_R = 25 V) (V_R = 35 V)	 MBD501 MBD701	I_R	 – –	 7.0 9.0	 200 200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)		V_F	–	1.0	1.2	Vdc
Series Inductance (f = 250 MHz, Lead Lenth ≈ 1/16")		L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Lenth ≈ 1/16")		C_C	–	0.18	–	pF

KRAKAUER METHOD OF MEASURING LIFE TIME



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – TOTAL CAPACITANCE

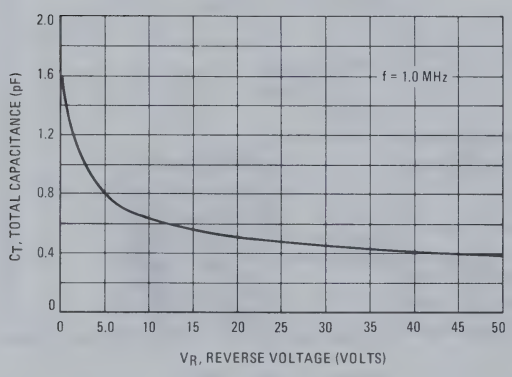


FIGURE 2 – MINORITY CARRIER LIFETIME

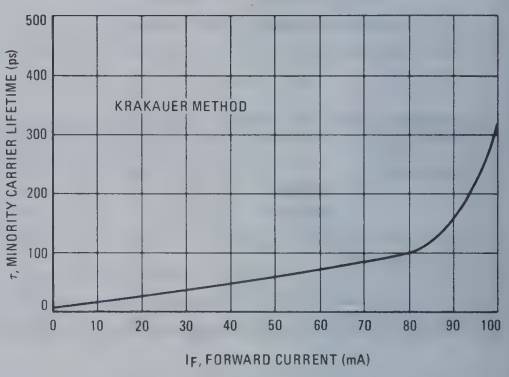


FIGURE 3 – REVERSE LEAKAGE

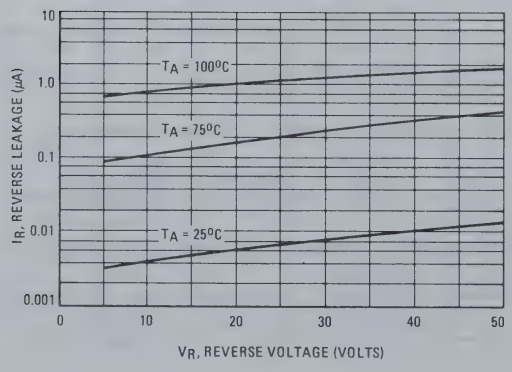
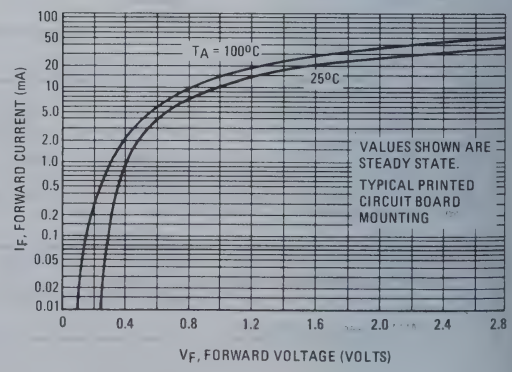


FIGURE 4 – FORWARD VOLTAGE



MBD502 (SILICON)
MBD702



SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in the low-inductance Mini-L package for low-cost, high-volume consumer and industrial/commercial requirements.

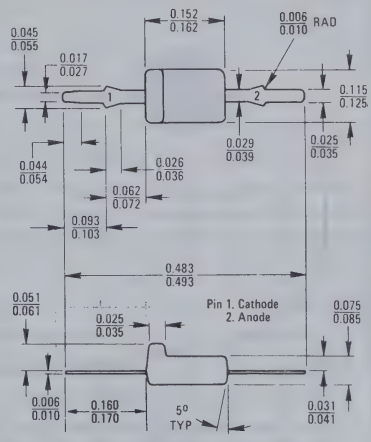
- The Schottky Barrier Construction Provides Ultra-Stable Characteristics by Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime – 100 ps (Max)
- Very Low Capacitance – 1.0 pF
- High Reverse Voltage – to 70 Volts
- Low Reverse Leakage – 200 nA (Max)
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

50-70 VOLTS



MBD502 Marked with Orange Color Stripe
MBD702 Marked with Brown Color Stripe



To convert inches to millimeters multiply by 25.4

CASE 226

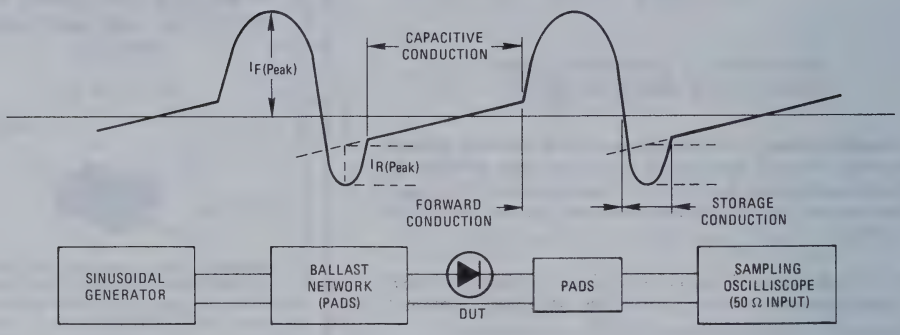
MAXIMUM RATING (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage MBD502 MBD702	V_R	 50 70	Volts
Forward Power Dissipation @ T_A = 25°C Derate Above 25°C	P_F	400 4.0	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc) MBD502 MBD702	$V_{(BR)R}$	 50 70	 – –	 – –	Volts
Diode Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)	C_T	–	0.48	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)	τ	–	15	100	ps
Reverse Leakage, Figure 3 (V_R = 25 V) MBD502 (V_R = 35 V) MBD702	I_R	 – –	 7.0 9.0	 200 200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)	V_F	–	1.0	1.2	Vdc
Series Inductance (f = 250 MHz, Measured at Lead Stop ≈ 1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

KRAKAUER METHOD OF MEASURING LIFE TIME



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – DIODE CAPACITANCE

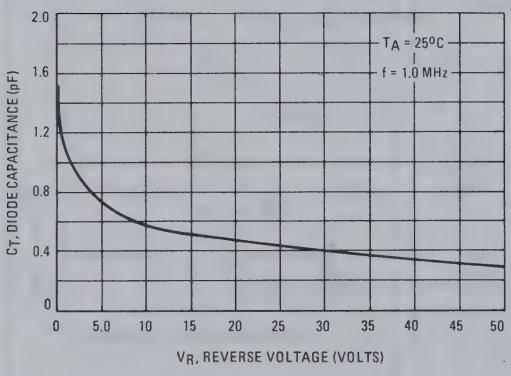


FIGURE 2 – MINORITY CARRIER LIFETIME

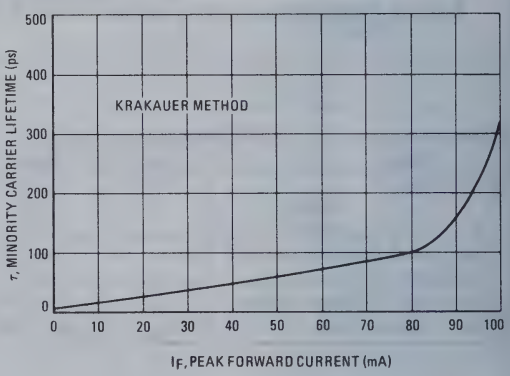


FIGURE 3 – REVERSE LEAKAGE

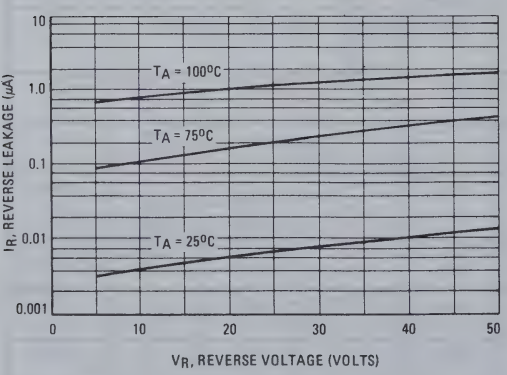
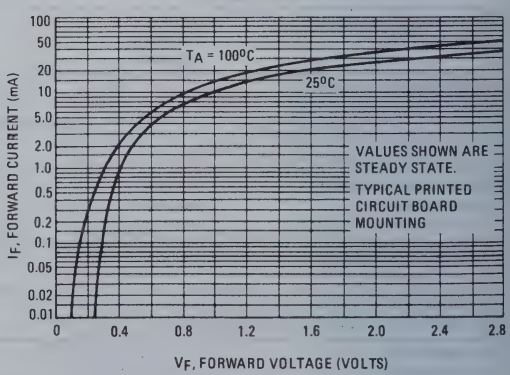


FIGURE 4 – FORWARD VOLTAGE



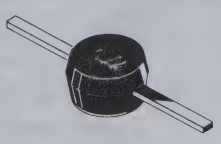
MBI-101 (SILICON)

SILICON HOT-CARRIER MICRO-I DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure – 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance – Less Than 1.0 pF @ Zero Volts
- High Forward Conductance – 0.48 Volts (Typ) @ I_F = 10 mA
- Supplied in Space Saving Miniature Package

SILICON HOT-CARRIER UHF MIXER MICRO-I DIODE



Device Marked with Yellow Top.

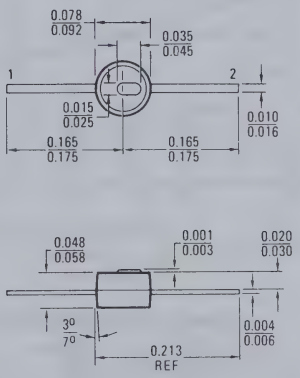
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	200 2.0	mW mW/°C
Operating Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F(1)	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	3.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.15	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.

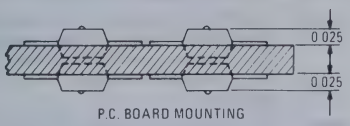


STYLE 1:
PIN 1. ANODE
2. CATHODE

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

CASE 166-02

TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



P.C. BOARD MOUNTING

Maximum Solder Temperature: 250°C for 10s

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

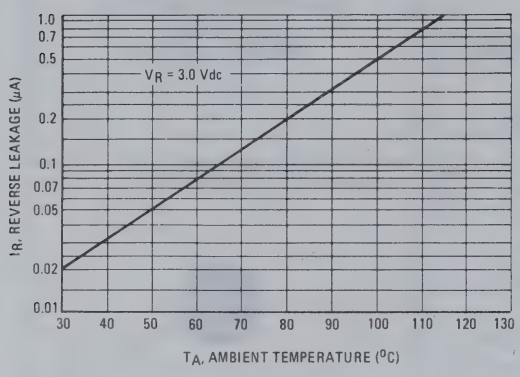


FIGURE 2 – FORWARD VOLTAGE

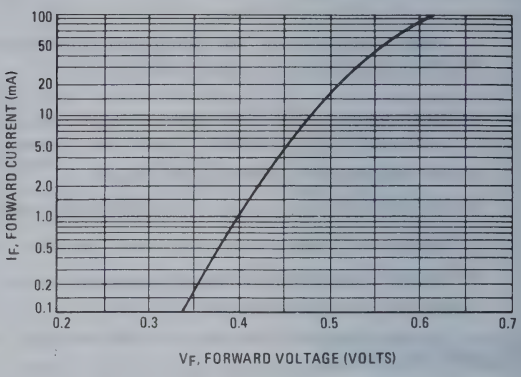


FIGURE 3 – CAPACITANCE

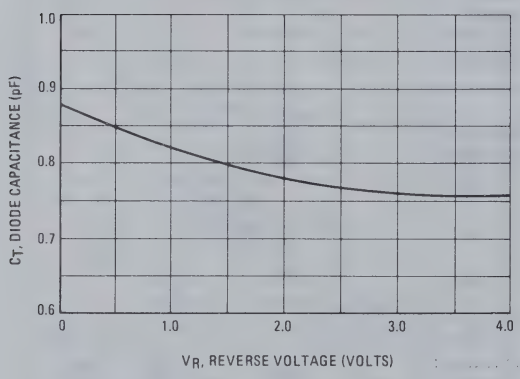


FIGURE 4 – NOISE FIGURE

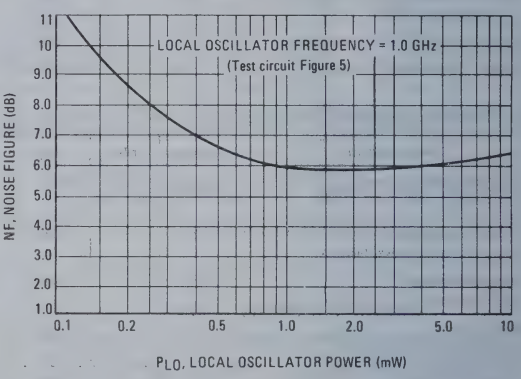
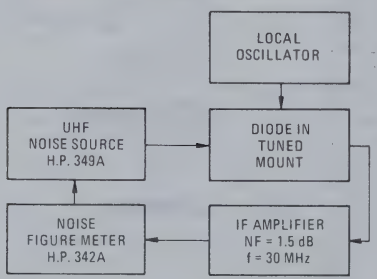


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBR320M
MBR330M
MBR340M

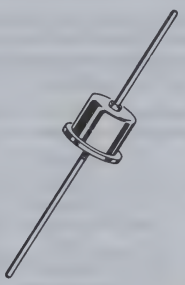
HOT CARRIER POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

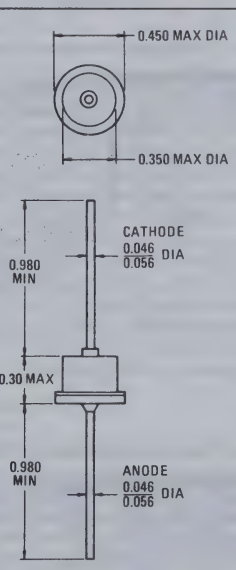
SCHOTTKY BARRIER RECTIFIERS

3 AMPERE
20, 30, 40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR320M	MBR330M	MBR340M	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2 V_R$ (dc), $T_C = 65^oC$ $V_{R(equiv)} \leq 0.2 V_R$ (dc), $T_L = 90^oC$ ($R_{\theta JA} = 25^oC/W$, P.C. Board Mounting, See Note 3)	I_O	← 15 → ← 3.0 →			Amp
Ambient Temperature Rated V_R (dc), $P_{F(AV)} = 0$ $R_{\theta JA} = 25^oC/W$	T_A	65	60	55	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC



CASE 60

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 5.0 Amp)	v_F	–	0.450	–	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 25^oC$ $T_C = 100^oC$	I_R	– –	– –	10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal leads are readily solderable.

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 125°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{IN(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR340M operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 10°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (1.41)(10)(0.65) = 9.2$ V

Step 2: Find T_R from Figure 3. Read T_R = 117°C @ V_R = 9.2 V & $R_{\theta JA}$ = 10°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 6.3 W @ $\frac{I_{(PK)}}{I_{(AV)}} = 10$ & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)} = 117-(10)(6.3) = 54°C$.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$ (2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR320M

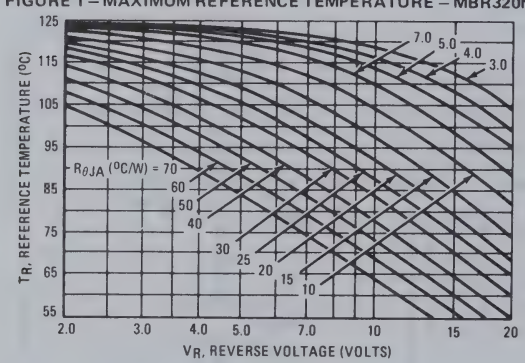


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR330M

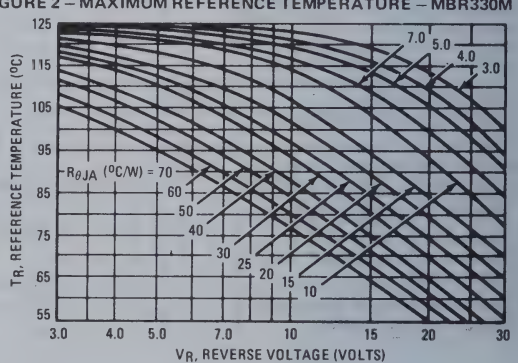


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR340M

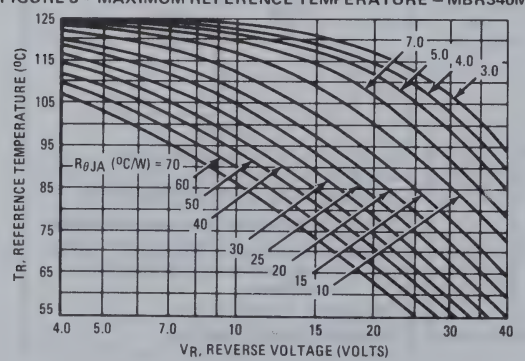
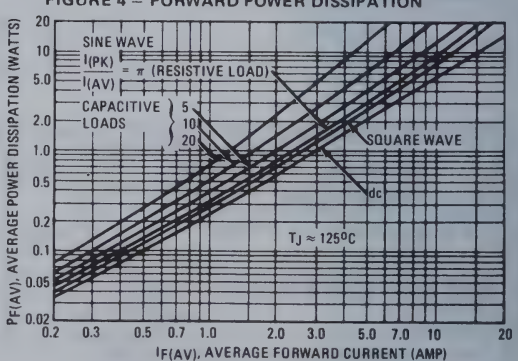
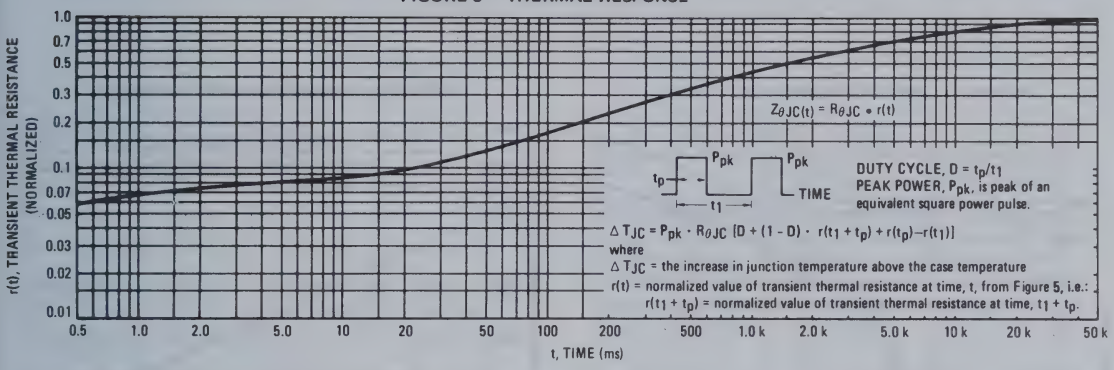


FIGURE 4 – FORWARD POWER DISSIPATION

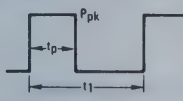


THERMAL CHARACTERISTICS

FIGURE 5 – THERMAL RESPONSE



NOTE 2 – FINDING JUNCTION TEMPERATURE



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

r(t) = normalized value of transient thermal resistance at time, t, from Figure 5 i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

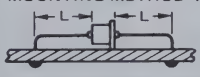
NOTE 3 – MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering.

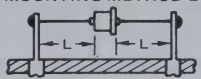
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)		$R_{\theta JA}$
	1/4	1	
1	55	60	°C/W
2	65	70	°C/W
3	25		°C/W

MOUNTING METHOD 1



MOUNTING METHOD 2



Vector pin mounting

MOUNTING METHOD 3

P. C. Board with 2 1/2" x 2 1/2" copper surface

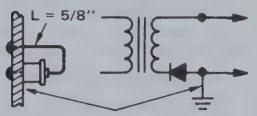
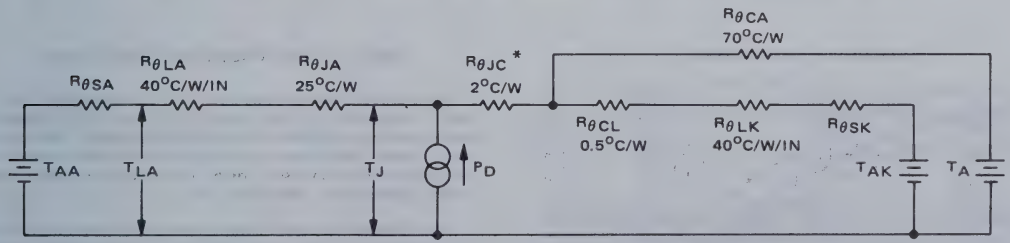


FIGURE 6 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits calculation of average junction temperature for any mounting situation. Lowest values of thermal resistance will occur when the cathode lead is brought as close as possible to a heat dissipator; as heat conduction through the anode lead is small. Terms in the model are defined as follows:

*Case temperature reference is at cathode end.

TEMPERATURES

T_A = Ambient
T_{AA} = Anode Heat Sink Ambient
T_{AK} = Cathode Heat Sink Ambient
T_{LA} = Anode Lead
T_{LK} = Cathode Lead
T_J = Junction

THERMAL RESISTANCES

$R_{\theta CA}$ = Case to Ambient
$R_{\theta SA}$ = Anode Lead Heat Sink to Ambient
$R_{\theta SK}$ = Cathode Lead Heat Sink to Ambient
$R_{\theta LA}$ = Anode Lead
$R_{\theta LK}$ = Cathode Lead
$R_{\theta CL}$ = Case to Cathode Lead
$R_{\theta JC}$ = Junction to Case
$R_{\theta JA}$ = Junction to Anode Lead (S bend)

FIGURE 7 – TYPICAL FORWARD VOLTAGE

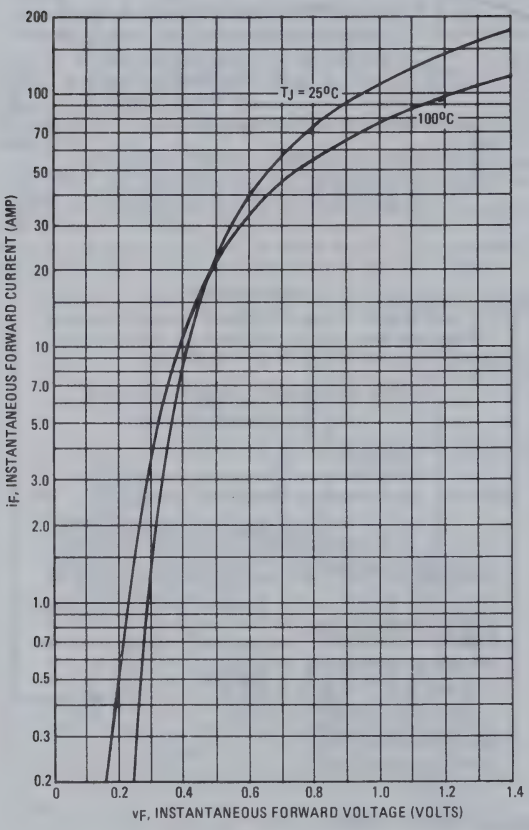


FIGURE 8 – MAXIMUM SURGE CAPABILITY

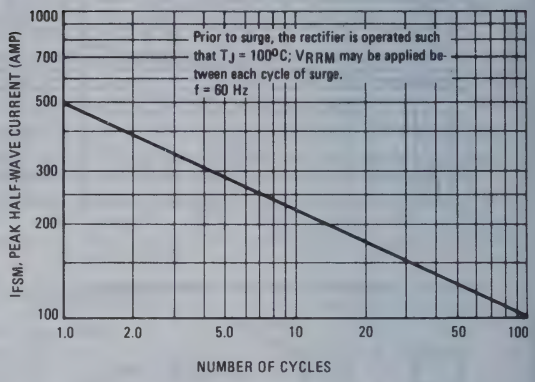


FIGURE 9 – TYPICAL REVERSE CURRENT

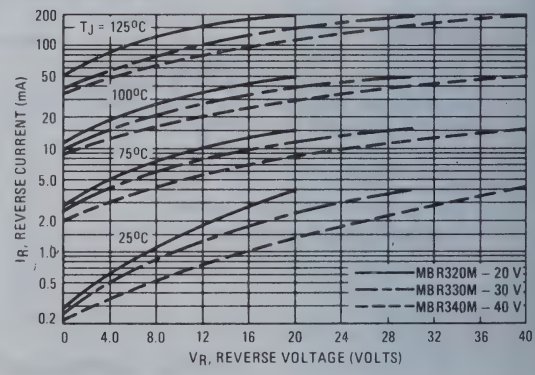
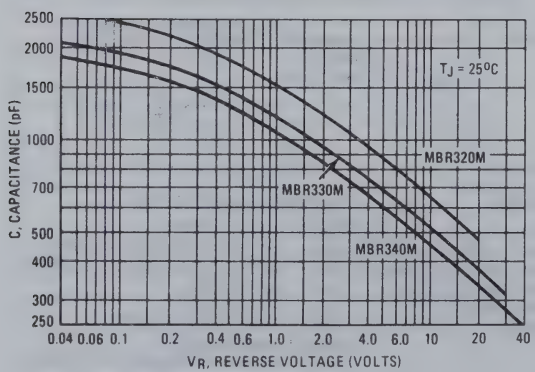


FIGURE 10 – CAPACITANCE



NOTE 4 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR1520
MBR1530
MBR1540

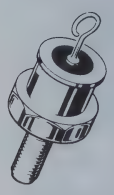
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

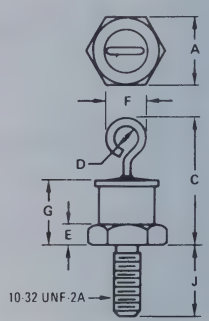
SCHOTTKY BARRIER RECTIFIERS

15 AMPERE 20,30,40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR1520	MBR1530	MBR1540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current ($V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 80^oC$	I_O	← 15 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 5.0^oC/W$	T_A	95	90	85	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.424	0.437	10.77	11.10
C	–	0.800	–	20.32
D	0.060	–	1.52	–
E	0.075	0.175	1.91	4.45
F	–	0.250	–	6.35
G	–	0.405	–	10.29
J	0.422	0.453	10.72	11.51

CASE 245

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 15 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	I_R	– –	– –	10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 15 in. lb. max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR1540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)} = (1.41)(10)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read T_R = 121°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 10.5 W @ $\frac{I_{(PK)}}{I_{(AV)}} = 20$ & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 121-(5)(10.5) = 68.5°C).

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1)(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR1520

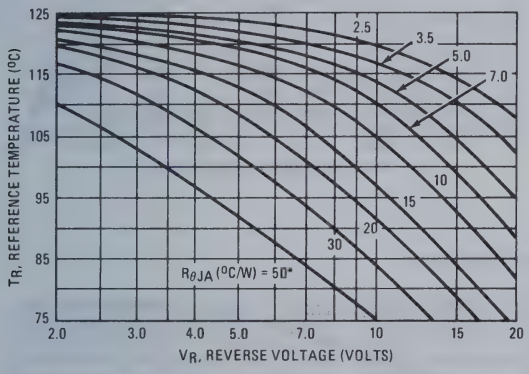


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR1530

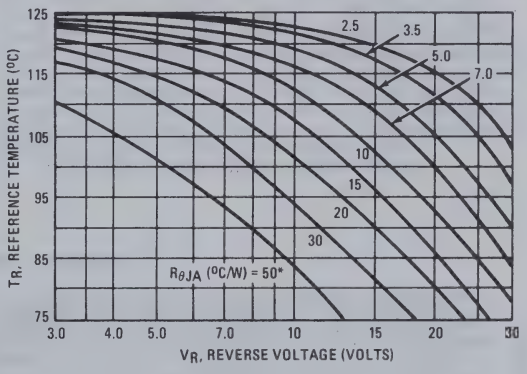
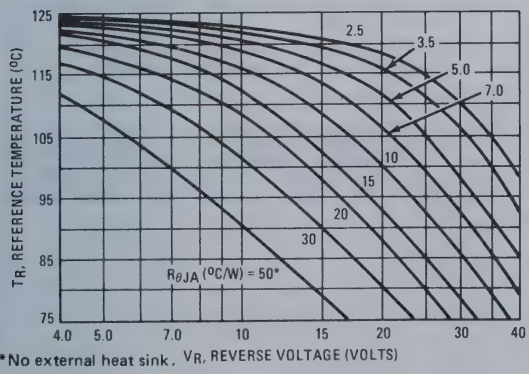


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR1540



*No external heat sink.

FIGURE 4 – FORWARD POWER DISSIPATION

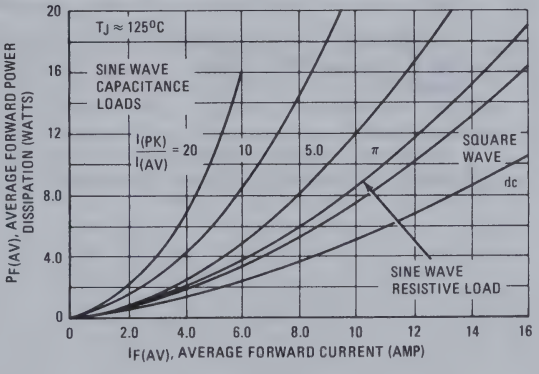


FIGURE 5 – TYPICAL FORWARD VOLTAGE

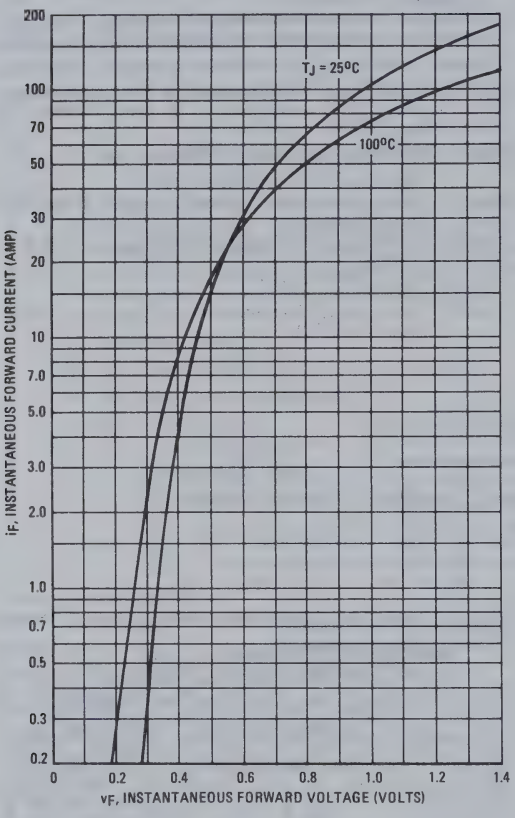


FIGURE 6 – MAXIMUM SURGE CAPABILITY

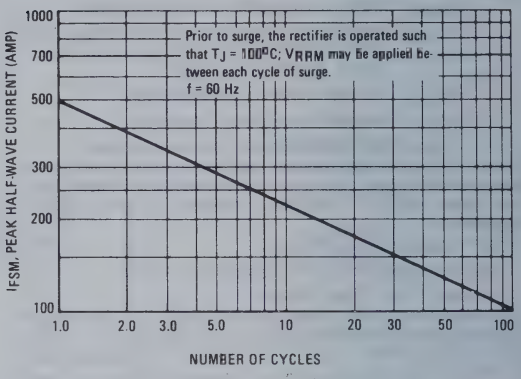


FIGURE 7 – CURRENT DERATING

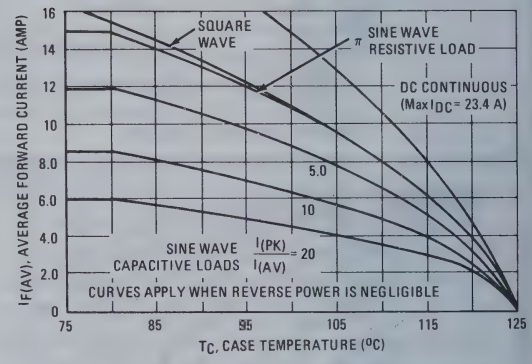


FIGURE 8 – THERMAL RESPONSE

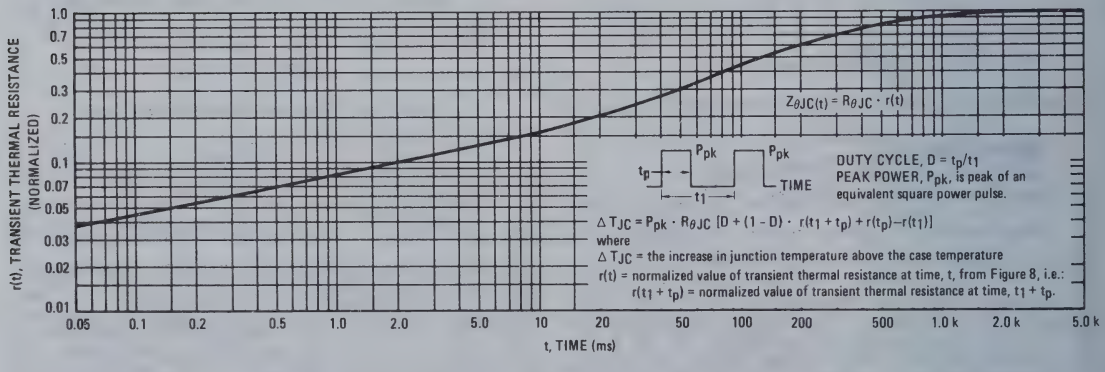


FIGURE 9 – NORMALIZED REVERSE CURRENT

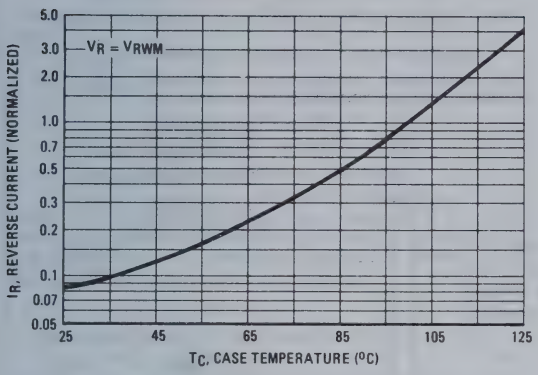


FIGURE 10 – TYPICAL REVERSE CURRENT

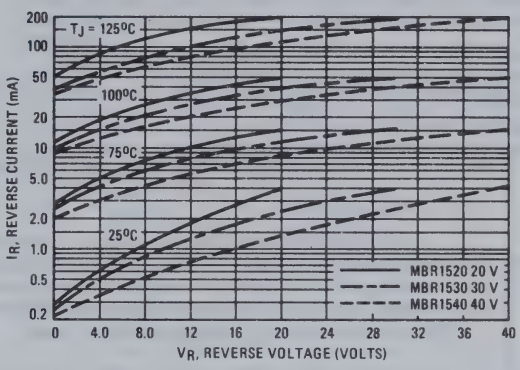
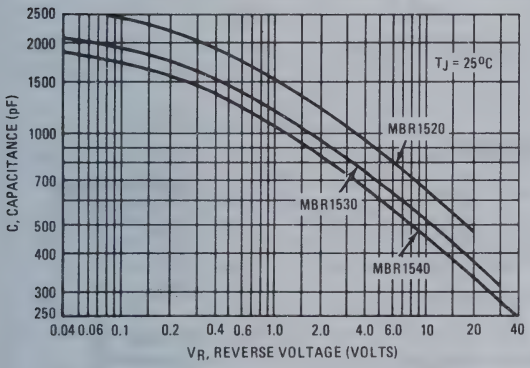


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR2520
MBR2530
MBR2540

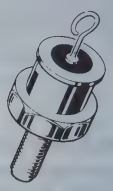
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

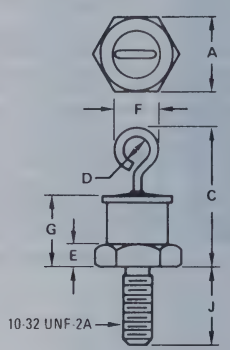
SCHOTTKY BARRIER RECTIFIERS

25 AMPERE
20, 30, 40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR2520	MBR2530	MBR2540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv.)} \leq 0.2\ V_{R(dc)}$, $T_C = 80^oC$	I_O	25			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 3.5^oC/W$	T_A	90	85	80	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	800 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	−65 to +125			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	150			^oC



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.424	0.437	10.77	11.10
C	–	0.800	–	20.32
D	0.060	–	1.52	–
E	0.075	0.175	1.91	4.45
F	–	0.250	–	6.35
G	–	0.405	–	10.29
J	0.422	0.453	10.72	11.51

CASE 245

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 25 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1) ($T_C = 100^oC$) ($T_C = 25^oC$)	I_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistance and terminal lead is readily solderable.
POLARITY: Cathode to Case
MOUNTING POSITIONS: Any
STUD TORQUE: 15 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR2540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 16 A ($I_{F(AV)}$ = 8 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (1.41)(10)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read T_R = 113°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 14.8 W @ $\frac{I_{(PK)}}{I_{(AV)}} = 20$ & $I_{F(AV)}$ = 8 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 113-(5)(14.8) = 39°C

TABLE I – VALUES FOR FACTOR F

Circuit / Load	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR2520

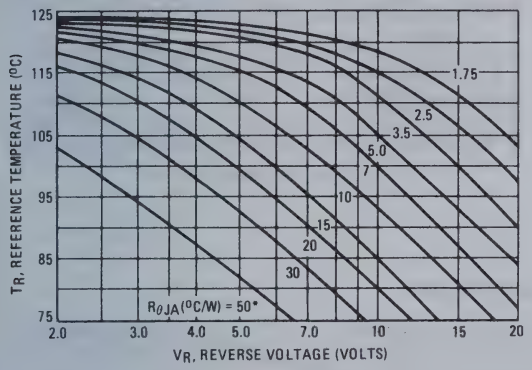


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR2530

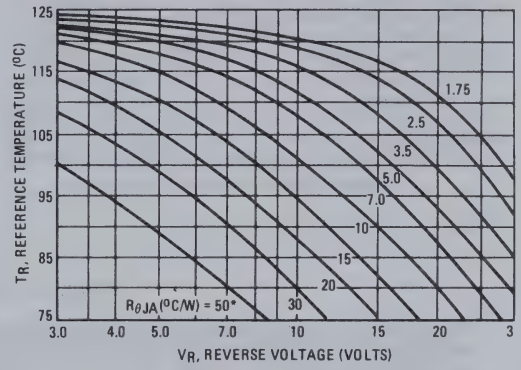
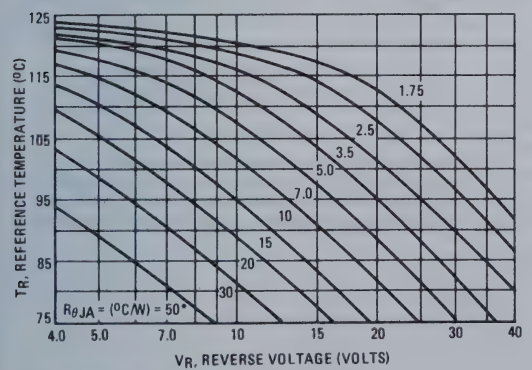


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR2540



*No external heat sink

FIGURE 4 – FORWARD POWER DISSIPATION

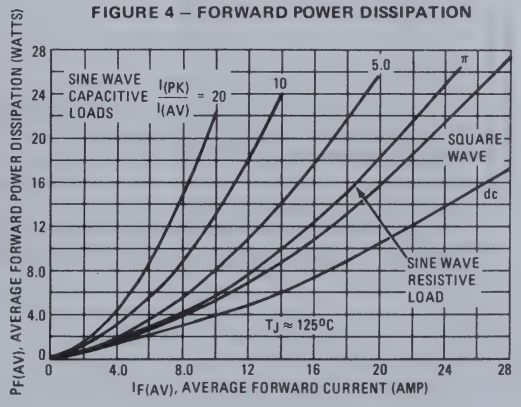


FIGURE 5 – TYPICAL FORWARD VOLTAGE

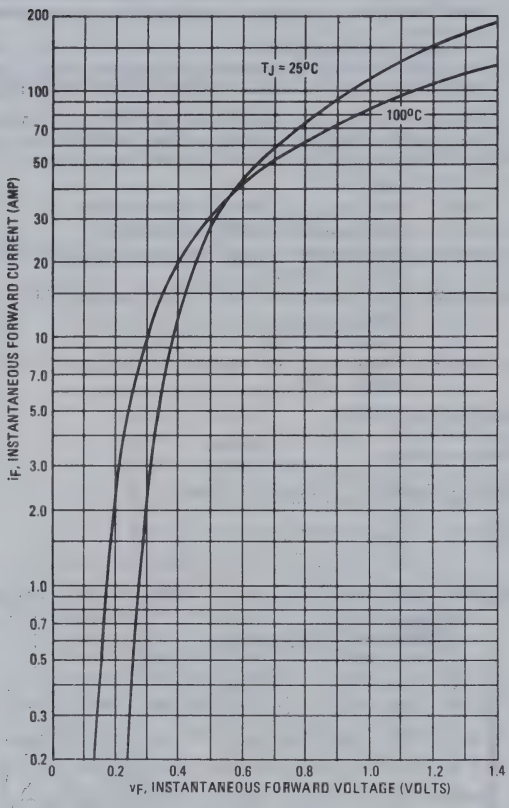


FIGURE 6 – MAXIMUM SURGE CAPABILITY

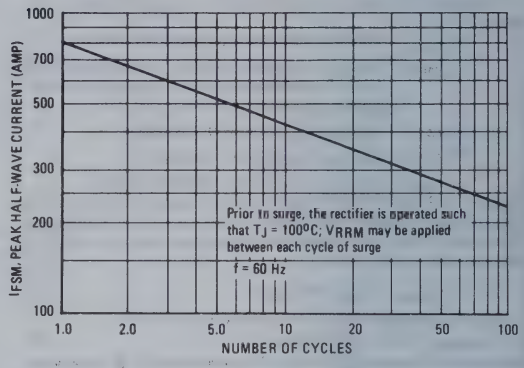


FIGURE 7 – CURRENT DERATING

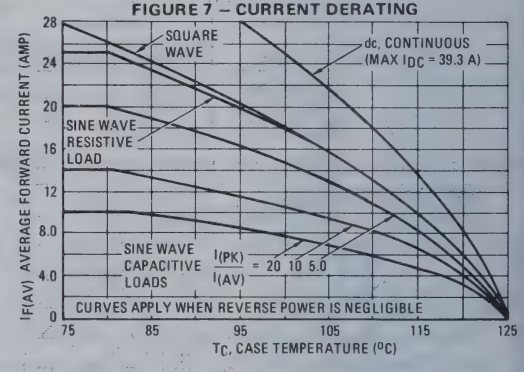


FIGURE 8 – THERMAL RESPONSE

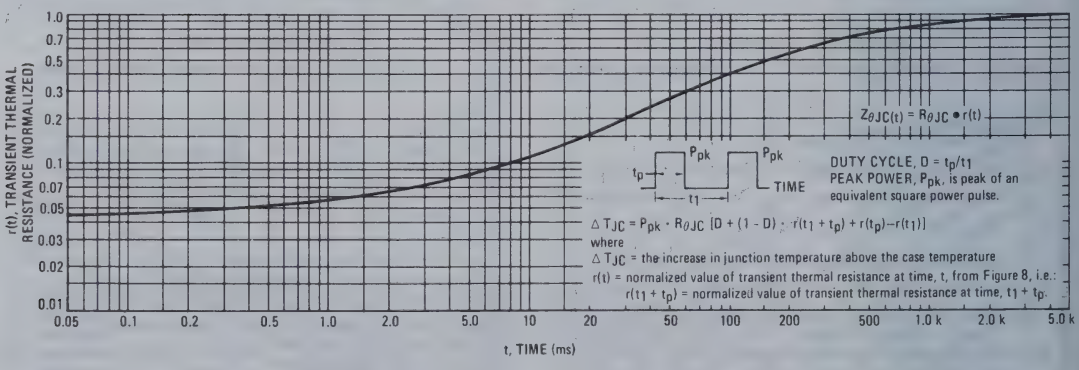


FIGURE 9 – NORMALIZED REVERSE CURRENT

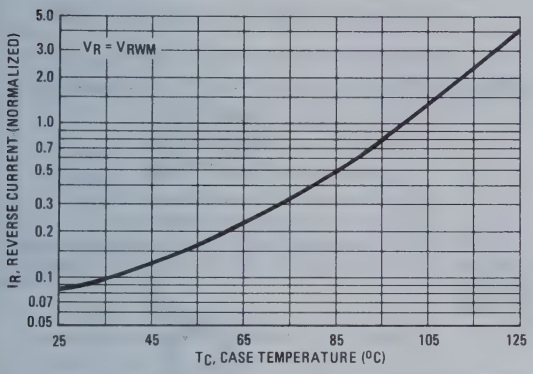


FIGURE 10 – TYPICAL REVERSE CURRENT

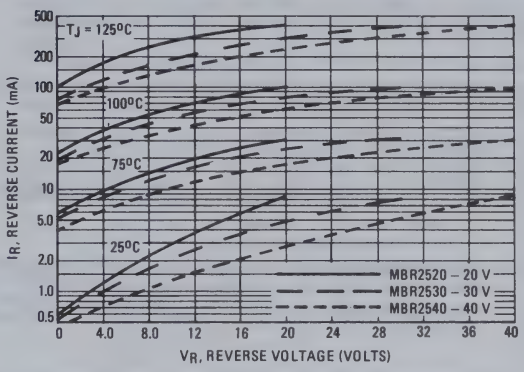
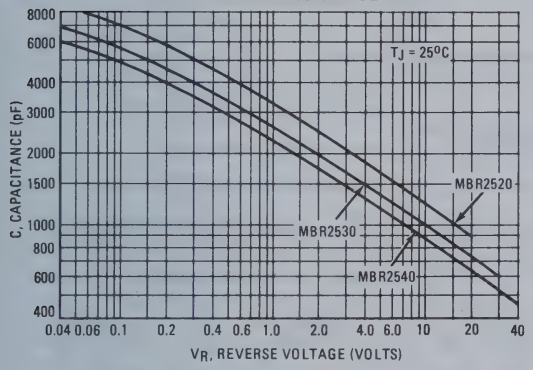


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR4020
MBR4030
MBR4040

HOT CARRIER POWER RECTIFIER

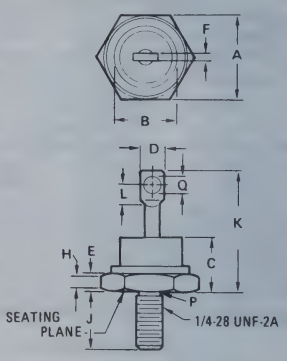
. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE 20,30,40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.667	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
H	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.96	–	0.152	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175

NOTES:
1. Dimension "P" is diameter.
2. All JEDEC dimensions and notes apply.

CASE 257-01
DO-5

MAXIMUM RATINGS

Rating	Symbol	MBR4020	MBR4030	MBR4040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 70^oC$	I_O	← 40 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 2.0^oC/W$	T_A	100	95	90	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 40 Amp)	v_F	–	–	0.630	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	I_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 125°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR4040 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA} = 3°C/W$.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)} = (10)(1.41)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read $T_R = 118°C$ @ $V_R = 9.18$ V & $R_{\theta JA} = 3°C/W$

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)} = 25$ W @ $\frac{I_{(PK)}}{I_{(AV)}} = 10$ & $I_{F(AV)} = 15$ A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)} = 118-(3)(25) = 43°C$.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR4020

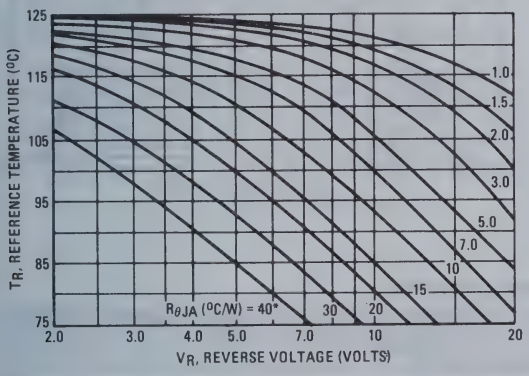


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR4030

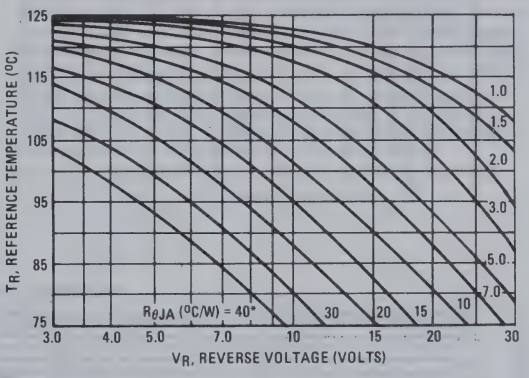
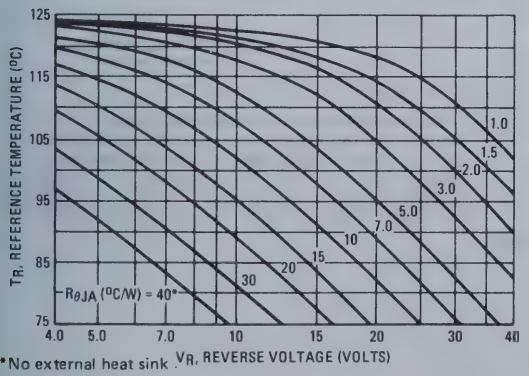


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR4040



*No external heat sink

FIGURE 4 – FORWARD POWER DISSIPATION

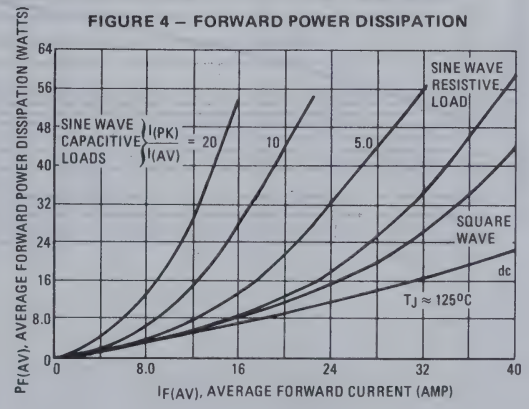


FIGURE 5 – TYPICAL FORWARD VOLTAGE

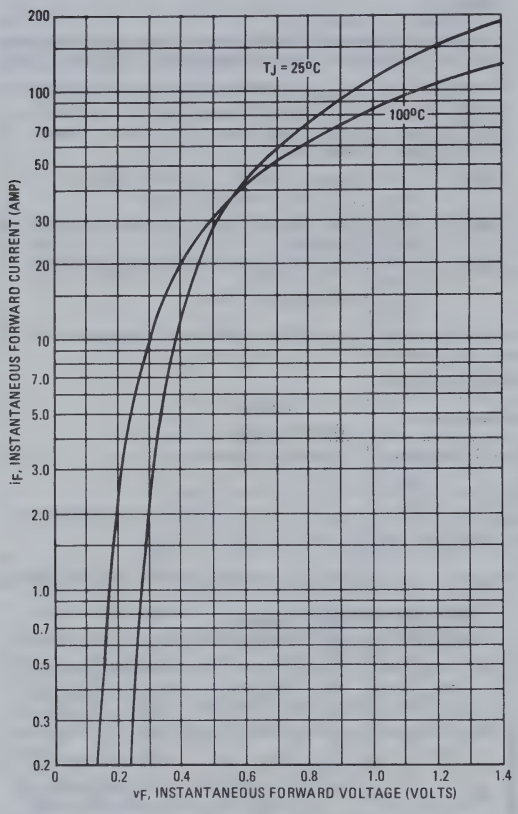


FIGURE 6 – MAXIMUM SURGE CAPABILITY

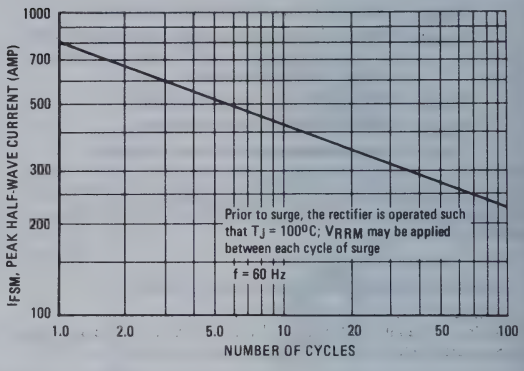


FIGURE 7 – CURRENT DERATING

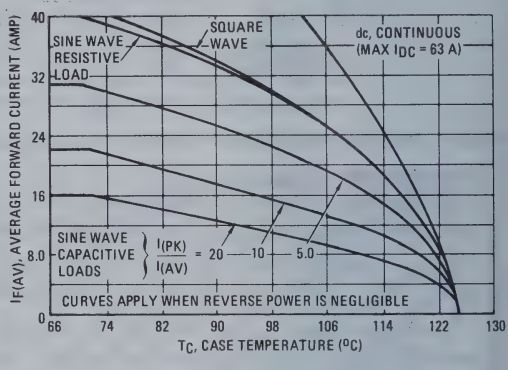


FIGURE 8 – THERMAL RESPONSE

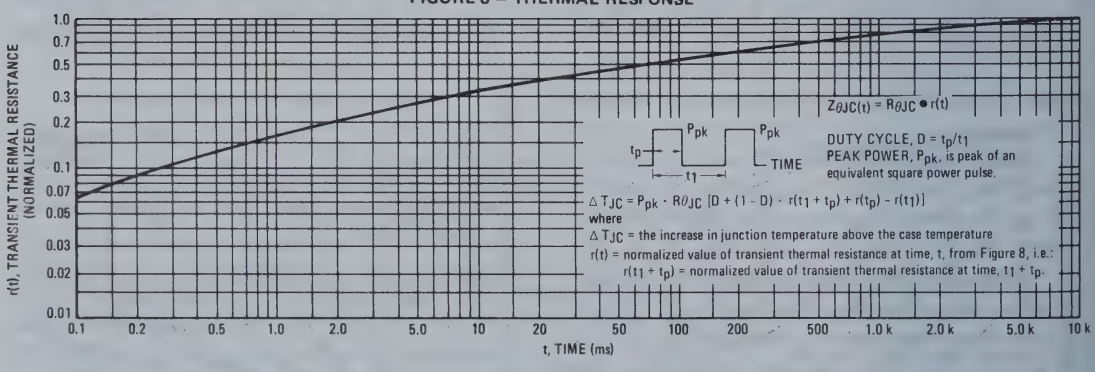


FIGURE 9 – NORMALIZED REVERSE CURRENT

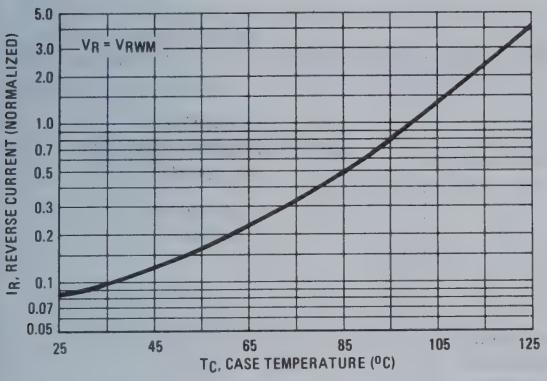


FIGURE 10 – TYPICAL REVERSE CURRENT

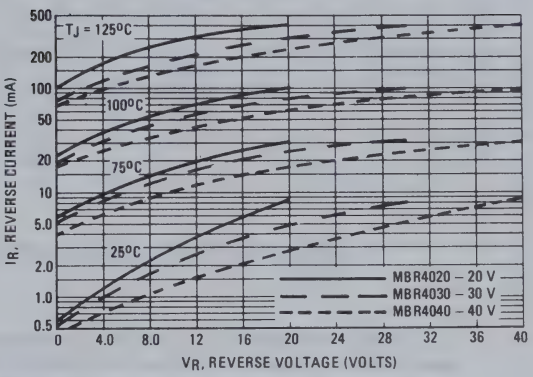
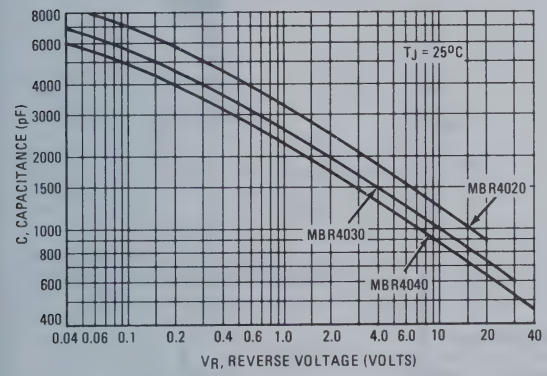


FIGURE 11 – CAPACITANCE



NOTE 2 HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBS100 (SILICON)



SILICON BIDIRECTIONAL SWITCH

. . . designed specifically for low cost lamp dimmer and small motor speed controls. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 4.0 Volts Typical
- Uniform Characteristics in Each Direction
- Minimizes "Flash-On" in a Lamp Dimmer
- Minimizes "Cogging" in a Motor Speed Control

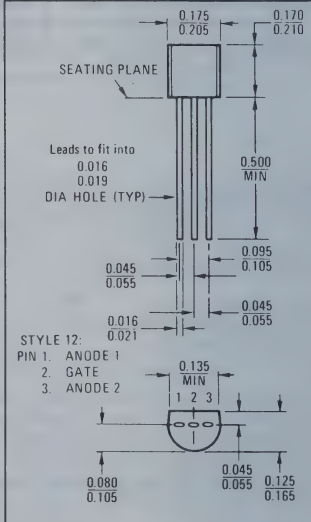
SILICON BIDIRECTIONAL SWITCH (PLASTIC)

3 to 5 VOLTS
500 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	500	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_G(off)$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM}(rep)$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM}(nonrep)$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



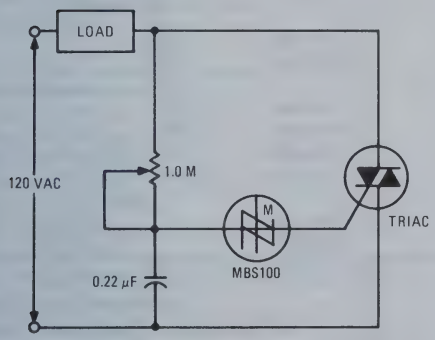
All JEDEC dimensions and notes apply

CASE 29-02
TO-92
PLASTIC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Switching Voltage	V_S	3.0	4.0	5.0	Vdc
Switching Current	I_S	100	–	400	μAdc
Switching Voltage Differential	$\|V_{S1}-V_{S2}\|$	–	–	0.35	Vdc
Holding Current	I_H	–	–	1.0	mAdc
Forward On-State Voltage (I_F = 175 mAdc)	V_F	–	–	2.0	Vdc
Voltage Switchback (I_F = 10 mAdc)	ΔV	2.0	2.8	–	Vdc

FIGURE 1 – FULL RANGE CONTROL CIRCUIT



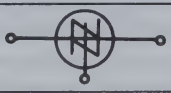
APPLICATION NOTE

The circuit shown in Figure 1 is for full range control and may be used as a lamp dimmer or small motor speed control. Lamp "flash-on" and motor "cogging" is minimized. Suggested triacs listed below give power capacity available for each device. The in-rush current and/or motor locked rotor current must be within the maximum multicycle surge rating for the triacs suggested.

TRIAC RECOMMENDATIONS

Triac	Package Type	Maximum Lamp Load	Maximum Motor Load	Maximum Single Cycle Surge
MAC77-4/2N6071	Case 77 (Plastic)	500 Watts	1/2 HP	30 A
MAC11-4	Case 90 (Plastic)	1500 Watts	1-1/2 HP	100 A
MAC37-4	Case 174 (Pressfit)	3000 Watts	3 HP	225 A
MAC38-4	Case 175 (Stud)	3000 Watts	3 HP	225 A

MBS4991 (SILICON)
MBS4992



SILICON BIDIRECTIONAL SWITCH

. . . designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering application and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.7 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02 %/°C Typical

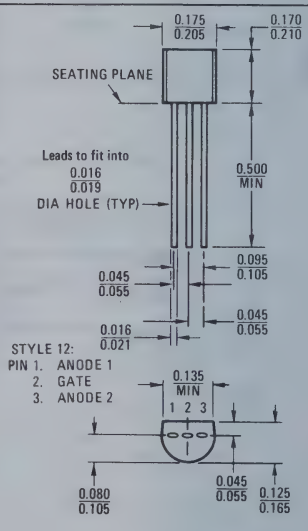
SILICON BIDIRECTIONAL SWITCH (PLASTIC)

6.0–10 VOLTS
500 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	500	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_G(off)$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM}(rep)$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM}(nonrep)$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



All JEDEC dimensions and notes apply

CASE 29-02
TO-92
PLASTIC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage		V_S				Vdc
	MBS4991		6.0	8.0	10	
	MBS4992		7.5	8.0	9.0	
Switching Current		I_S				μAdc
	MBS4991		–	175	500	
	MBS4992		–	90	120	
Switching Voltage Differential		$\lvert V_{S1}-V_{S2}\rvert$				Vdc
	MBS4991		–	0.3	0.5	
	MBS4992		–	0.1	0.2	
Gate Trigger Current		I_{GF}				μAdc
(V_F = 5.0 Vdc R_L = 1.0 K ohm)	MBS4992		–	–	100	
Holding Current		I_H				mAdc
	MBS4991		–	0.7	1.5	
	MBS4992		–	0.2	0.5	
Off-State Blocking Current		I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4991		–	0.08	1.0	
(V_F = 5.0 Vdc, T_A = 85°C)	MBS4991		–	2.0	10	
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4992		–	0.08	0.1	
(V_F = 5.0 Vdc, T_A = 100°C)	MBS4992		–	6.0	10	
Forward On-State Voltage		V_F				Vdc
(I_F = 175 mAdc)	MBS4991		–	1.4	1.7	
(I_F = 200 mAdc)	MBS4992		–	1.5	1.7	
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, (Figure 7)		V_o	3.5	4.8	–	Vdc
Turn-On Time (Figure 8)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 9)		t_{off}	–	30	–	μs
Temperature Coefficient of Switching Voltage (–50 to +125°C)		T_C	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE versus TEMPERATURE

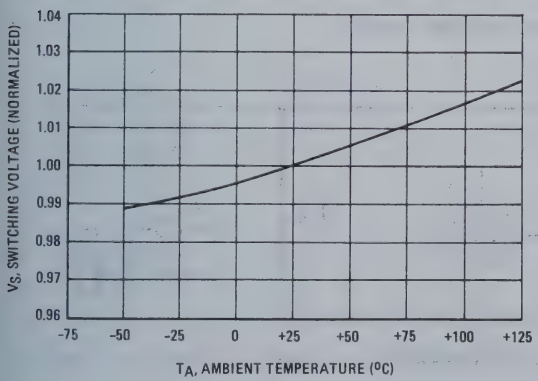


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

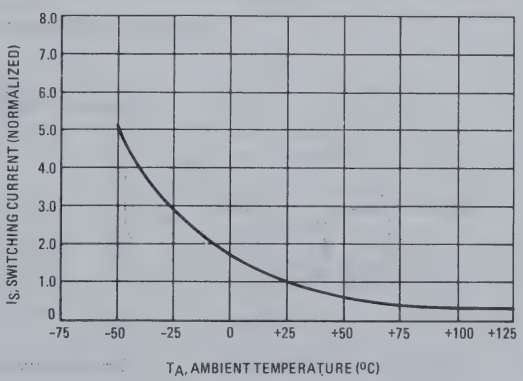


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

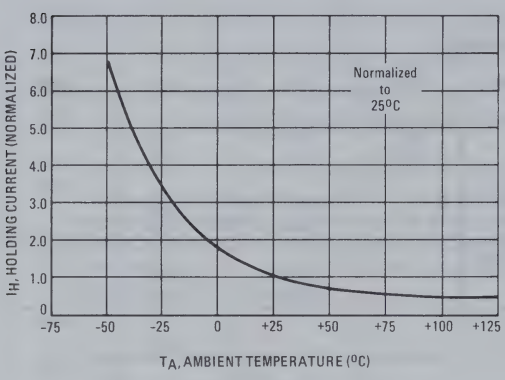


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

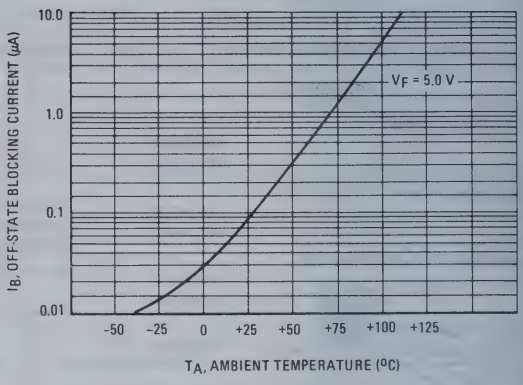


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

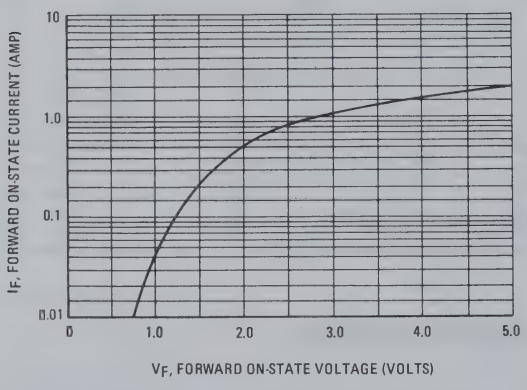


FIGURE 6 – PEAK OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

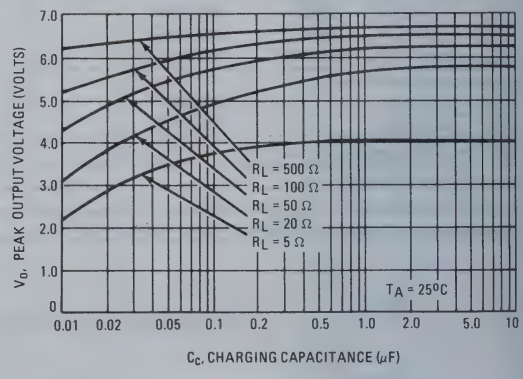


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

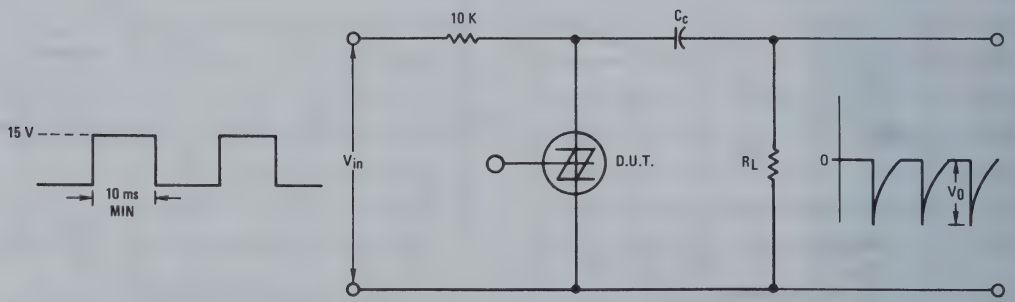
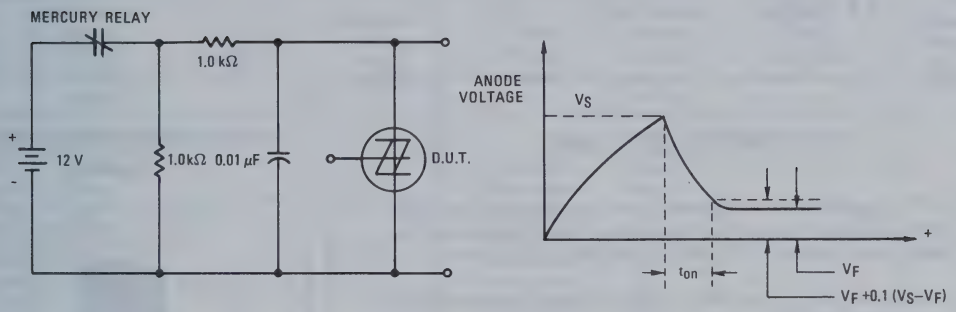
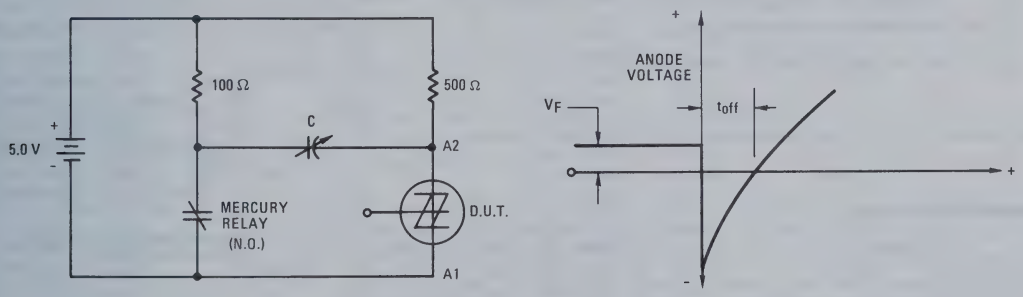


FIGURE 8 – TURN-ON TIME TEST CIRCUIT



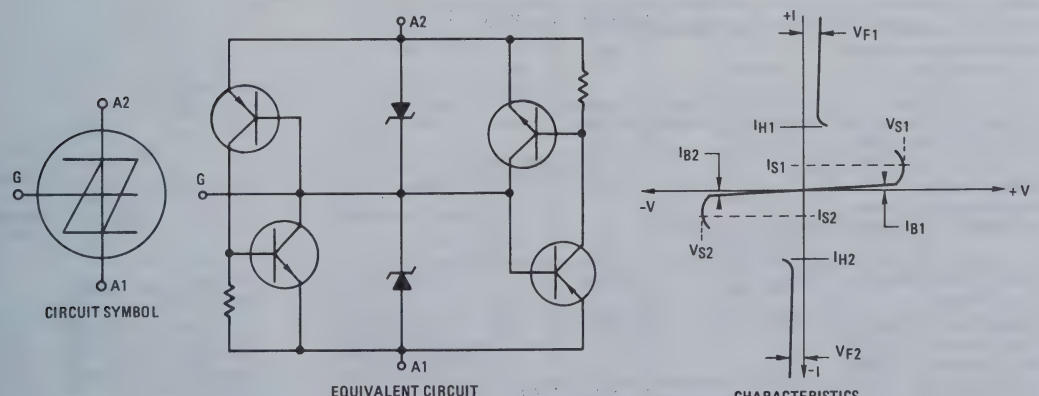
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT



With the SBS in conduction and the relay contacts open, close the contacts to cause anode A2 to be driven negative. Decrease C until the SBS just remains off when anode A2 becomes positive. The turn-off time, t_{off}, is the time from initial contact closure and until anode A2 voltage reaches zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS



MCA1911N, P series MCA2011N, P series (SILICON)

6.8 Volts **8.6 Volts**

MCA2111N, P series

9.5 Volts

MCA2211N, P series

11 Volts

REFERENCE AMPLIFIERS

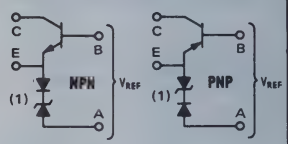
. . . designed for use in regulated power supplies as a combination voltage reference element and error voltage amplifier, providing temperature compensation for excellent reference voltage stability.

- Available With Either PNP or NPN Polarity for Versatility of Circuit Design
- Specified With a Variety of Reference Voltage Stability Factors Allowing for a Wide Selection of the Most Economical Device to Meet Circuit Requirements
- Available for Operation in Three Different Test Temperature Ranges: 0 to +75°C, -55 to +100°C, -55 to +150°C
- Guaranteed Maximum Impedance
- "In-Line" Leads – Ideal for Automatic Insertion

REFERENCE AMPLIFIERS

DS 6039 R1





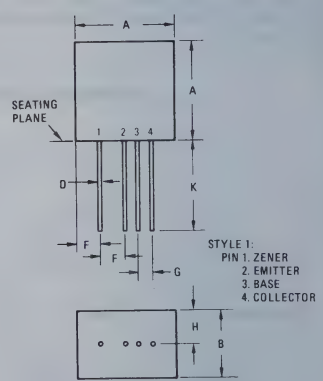
(1) MCA1911 Series uses only zener diode and transistor.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Zener Current	I_Z	20	mA
Collector Current	I_C	20	mA
Collector-Emitter Voltage	V_{CEO}	30	Volts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value		Unit
Nominal Reference Voltage (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	V_{REF}	6.8 – 11 (Nom) (Table 1)		Volts
Maximum Reference Voltage Change with Temperature (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	ΔV_{REF}	(Table 1)		Volts
		Min	Max	
Zener Impedance (I_{ZT} = 5.0 mA, I_{ac} = 10% I_Z) MCA1911N, P; MCA2011N,P; MCA2111N,P; Series MCA2211N,P Series	Z_{ZT}	— —	40 120	ohms
Collector-Emitter Breakdown Voltage (I_C = 250 μA)	BV_{CEO}	30	—	Volts
Collector-Cutoff Current (V_{CB} = 45 V) (V_{CB} = 45 V, T_A = 150°C)	I_{CBO}	— —	0.05 10	μA
DC Current Gain (I_C = 250 μA, V_{CE} = 3.0 V)	h_{FE}	50	300	—
Small-Signal Transconductance (V_{CE} = 3.0 V, I_C = 250 μA, f = 1.0 kHz)	g_{fe}	6500	—	μmhos



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.65	10.41	0.380	0.410
B	7.62	8.13	0.300	0.320
D	0.46	0.56	0.018	0.022
F	2.29	2.79	0.090	0.110
G	1.02	1.52	0.040	0.060
H	3.68	4.19	0.145	0.165
K	9.53	–	0.375	–

CASE 212-(2)
(Formerly Case 181)

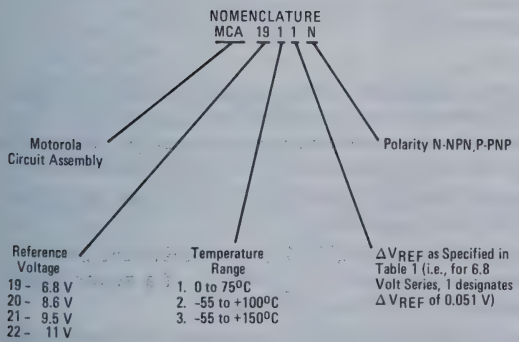
TABLE 1 – ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
6.8 Volt Series (I_{ZT} = 5 mA)			
MCA1911N	0.051	0, +25, +75	6.8 ± 10%
MCA1912N	0.025		
MCA1913N	0.010		
MCA1914N	0.005		
MCA1921N	0.105	-55, 0, +25, +75, +100	6.8 ± 5%
MCA1922N	0.052		
MCA1923N	0.020		
MCA1924N	0.010		
MCA1931N	0.139	-55, 0, +25, +75, +100, +150	6.8 ± 5%
MCA1932N	0.069		
MCA1933N	0.026		
MCA1934N	0.013		
9.5 Volt Series (I_{ZT} = 5 mA)			
MCA2111N	0.071	0, +25, +75	9.5 ± 10%
MCA2112N	0.035		
MCA2113N	0.014		
MCA2114N	0.007		
MCA2121N	0.147	-55, 0, +25, +75, +100	9.5 ± 5%
MCA2122N	0.073		
MCA2123N	0.028		
MCA2124N	0.014		
MCA2131N	0.194	-55, 0, +25, +75, +100, +150	9.5 ± 5%
MCA2132N	0.097		
MCA2133N	0.038		
MCA2134N	0.019		

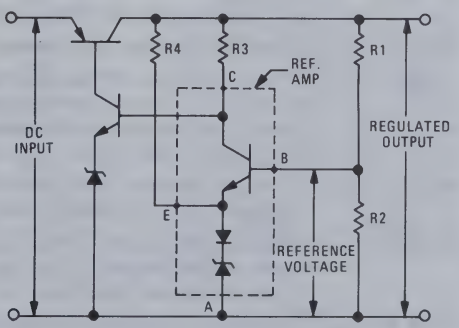
Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
8.6 Volt Series (I_{ZT} = 5 mA)			
MCA2011N	0.060	0, +25, +75	8.6 ± 10%
MCA2012N	0.030		
MCA2013N	0.012		
MCA2014N	0.006		
MCA2021N	0.124	-55, 0, +25, +75, +100	8.6 ± 5%
MCA2022N	0.062		
MCA2023N	0.024		
MCA2024N	0.012		
MCA2031N	0.164	-55, 0, +25, +75, +100, +150	8.6 ± 5%
MCA2032N	0.082		
MCA2033N	0.032		
MCA2034N	0.016		
11 Volt Series (I_{ZT} = 5 mA)			
MCA2211N	0.082	0, +25, +75	11 ± 10%
MCA2212N	0.041		
MCA2213N	0.016		
MCA2214N	0.008		
MCA2221N	0.170	-55, 0, +25, +75, +100	11 ± 5%
MCA2222N	0.085		
MCA2223N	0.034		
MCA2224N	0.017		
MCA2231N	0.225	-55, 0, +25, +75 +100, +150	11 ± 5%
MCA2232N	0.112		
MCA2233N	0.044		
MCA2234N	0.022		

NOTES:

1. Type numbers listed are NPN polarity. For PNP polarity devices substitute "P" suffix – e.g.: MCA1911N (NPN)
   MCA1911P (PNP)
2. ΔV_{REF} is the maximum voltage variation over the specified test temperature range, verified by tests at specified points within the range.

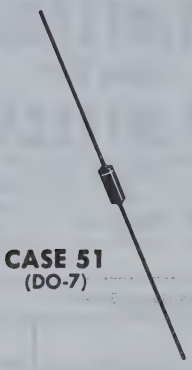


TYPICAL APPLICATION IN REGULATED POWER SUPPLIES



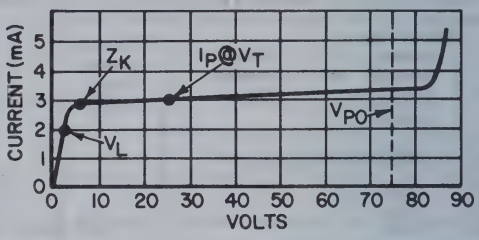
MCL1300 thru MCL1304 (SILICON)

Field-effect current limiting diodes designed for applications requiring a current reference or a constant current over a specified voltage range.



CASE 51
(DO-7)

CURRENT-LIMITER CHARACTERISTICS AND SYMBOL IDENTIFICATION
(See Notes 1 thru 6)



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Junction and Storage Temperature: -65°C to +200°C
Peak Operating Voltage: See Table

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Type Number	Nominal Pinch-Off Current Note 1 I_P (mA)	Tol. (mA)	Test Volt. Note 2 V_T (volts)	Limiter Imped. Note 3 Z_T (min) (megohms)	Knee Imped. at 6 V Note 4 Z_K (min) (megohms)	Limiting Voltage Note 5 V_L (max) (volts)	Peak Operating Voltage Note 6 V_{PO} (volts)
MCL1300	0.5	±0.3	25	4.000	0.500	1.0	75
MCL1301	1.0	±0.6	25	0.800	0.200	1.5	75
MCL1302	2.0	±0.6	25	0.400	0.100	2.0	75
MCL1303	3.0	±0.6	25	0.300	0.050	2.0	75
MCL1304	4.0	±0.6	25	0.250	0.025	2.5	75

These specifications are preliminary. Selections may be made to obtain nominal currents between those shown, as well as tighter tolerance units.

SYMBOL DEFINITIONS:

Note 1 I_P - The pinch-off current is the guaranteed current at a specified V_T. I_P is specified as a nominal with a tolerance.

Note 2 V_T - The test voltage for measurement of I_P.

Note 3 Z_T - The impedance at the test voltage, V_T, specified. To provide the most constant current Z_T should be as high as possible; thus a minimum Z_T is specified. Z_T is derived from the 90 cycle per second current which results when an AC voltage having an RMS value equal to 10% of the test voltage (V_T) is superimposed on V_T.

Note 4 Z_K - Knee impedance is specified as a minimum also since again the highest value is desired. V_K is established as 6.0 V for convenience.

Note 5 V_L - Limiting Voltage. This specification is provided with Z_K to indicate the sharp knee of the device. The specification is analogous to I_R and Z_K of a zener diode. V_L a maximum specification is measured at 80% on I_P tolerance.

Note 6 V_{PO} - The peak-operating voltage is provided and indicates the maximum voltage to be applied to the device. The specification is necessary since the device is either power limited or breakdown limited beyond this specified voltage.

MCR32 SERIES (SILICON)



SILICON CONTROLLED RECTIFIERS

. . . designed primarily for industrial applications. Ideally suited for capacitor-discharge ignition, systems, power switching and power control.

- Glass Passivated for High Reliability
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications
- High di/dt Capability

THYRISTORS

7 AMPERES RMS
50-600 VOLTS

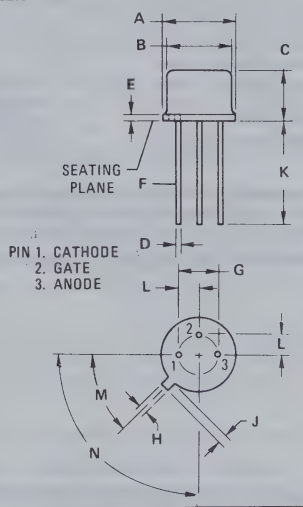


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR32- -05		50	
20		200	
30		300	
40		400	
50		500	
60		600	
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	7.0	Amps
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	80	Amps
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Forward Peak Gate Power, $T_A = 25^oC$	P_{GM}	10	Watts
Forward Average Gate Power, $T_A = 25^oC$	$P_{GF(AV)}$	0.5	Watt
Forward Peak Gate Current, $T_A = 25^oC$ (300 μs, 120 PPS)	I_{GFM}	10	Amps
Reverse Peak Gate Voltage	V_{GRM}	4.0	Volts
Operating Junction Temperature Range	T_J	-40 to +135	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	$^oC/W$



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.890	9.400	0.350	0.370
B	8.000	8.510	0.315	0.335
C	6.100	6.600	0.240	0.260
D	0.406	0.483	0.016	0.019
E	0.229	3.180	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.830	5.330	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.020	0.029	0.040
K	12.700	–	0.500	–
L	2.540 TP		0.100 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1)	V_{DRM}			Volts
MCR32-05		50	–	
MCR32-20		200	–	
MCR32-30		300	–	
MCR32-40		400	–	
MCR32-50		500	–	
MCR32-60		600	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 135°C)	I_{DRM}	–	1.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 135°C)	I_{RRM}	–	1.0	mA
Forward "On" Voltage (2) (I_{TM} = 30 A peak @ T_C = 25°C)	V_{TM}	–	2.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	I_{GT}	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	V_{GT}	–	1.5	Volts
Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 30 Ohms, T_C = 135°C)	V_{GD}	0.1	–	Volts
Holding Current (Gate Open, T_C = 25°C)	I_H	–	20	mA

(1) Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

(2) Forward current applied for 1.0 ms maximum duration, duty cycle ≤1.0%.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

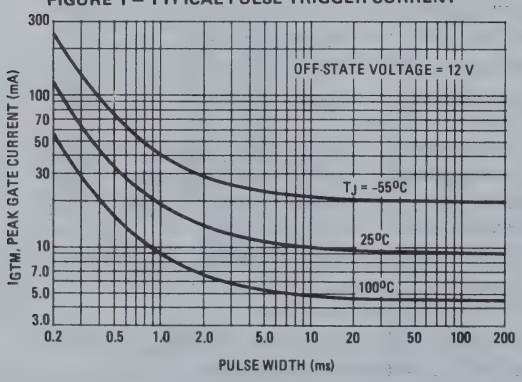


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

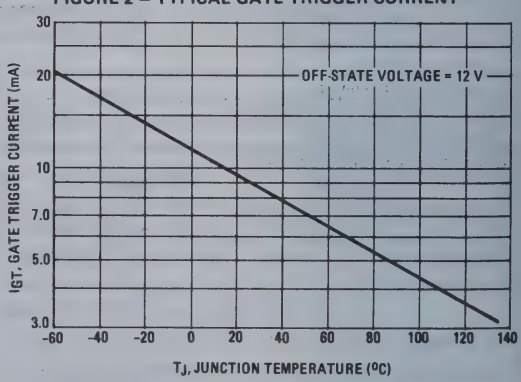


FIGURE 3 – MAXIMUM ON-STATE POWER DISSIPATION

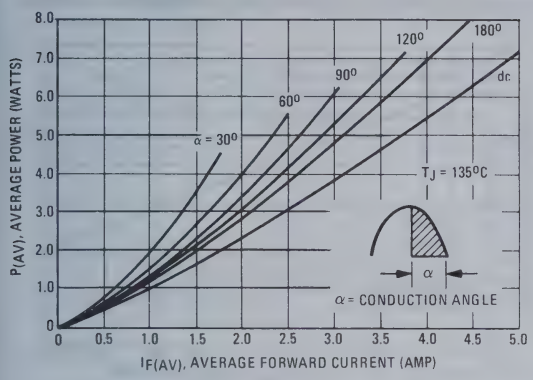


FIGURE 4 – AVERAGE CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

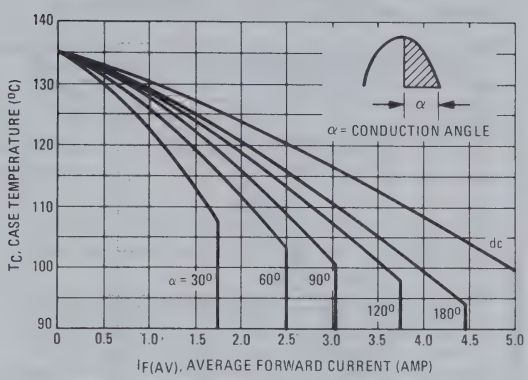


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE 4 in. sq. P.C. BOARD)

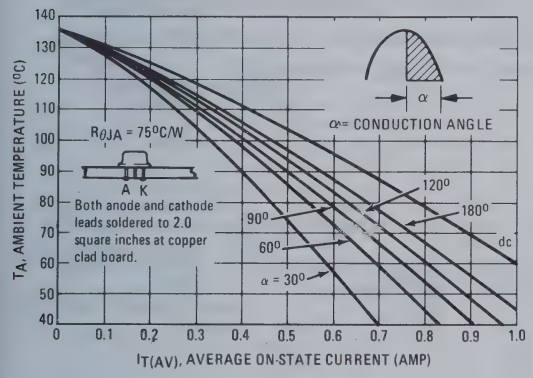


FIGURE 6 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE , TYPICAL P.C. BOARD MOUNTING)

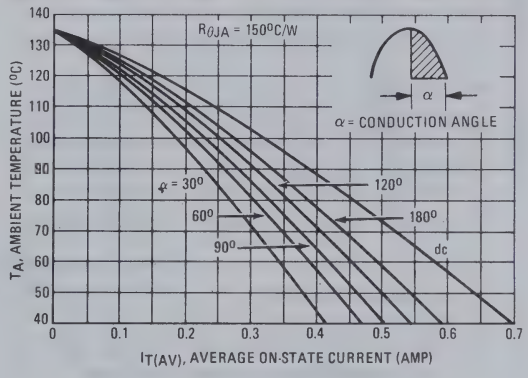


FIGURE 7 – TYPICAL GATE TRIGGER VOLTAGE

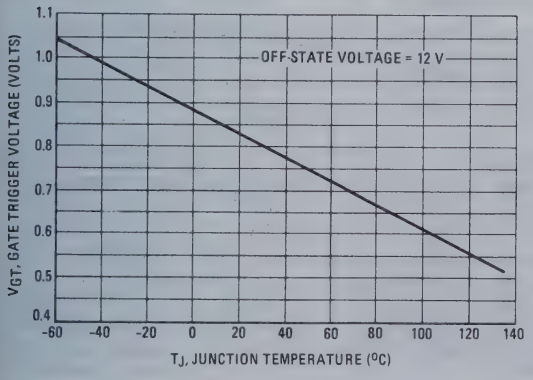


FIGURE 8 – TYPICAL HOLDING CURRENT

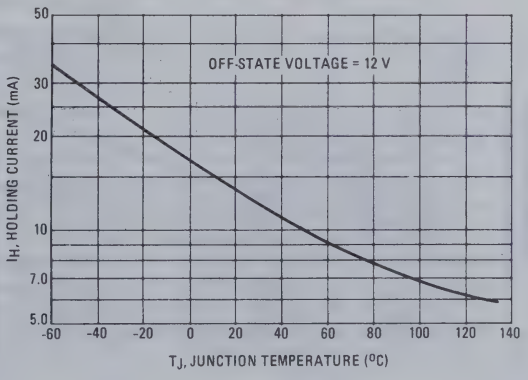


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

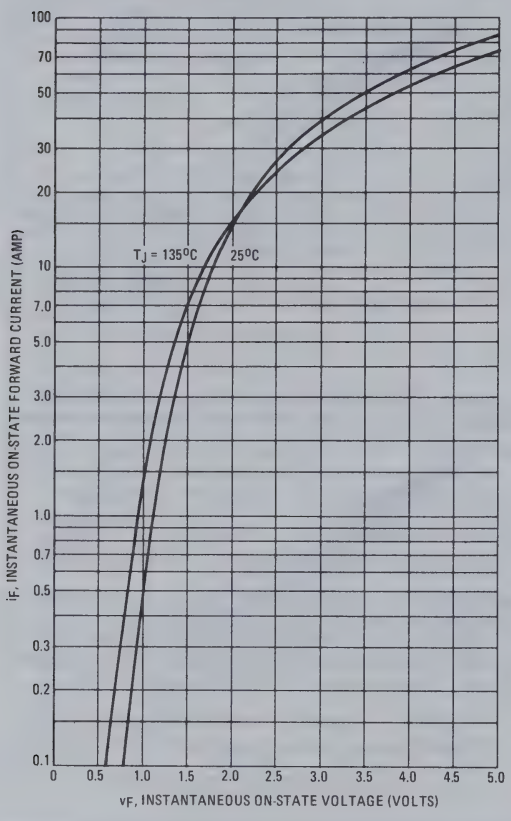


FIGURE 10 – MAXIMUM NON-REPETITIVE SURGE CURRENT

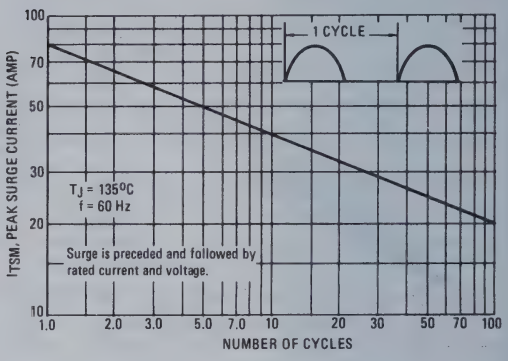


FIGURE 11 – CHARACTERISTICS AND SYMBOLS

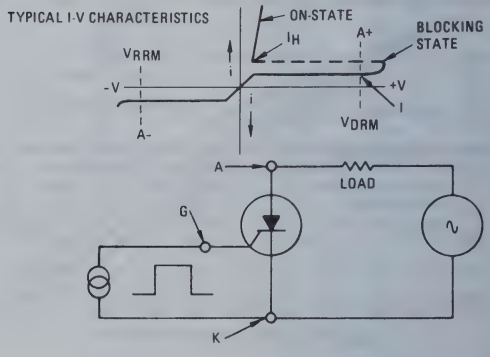
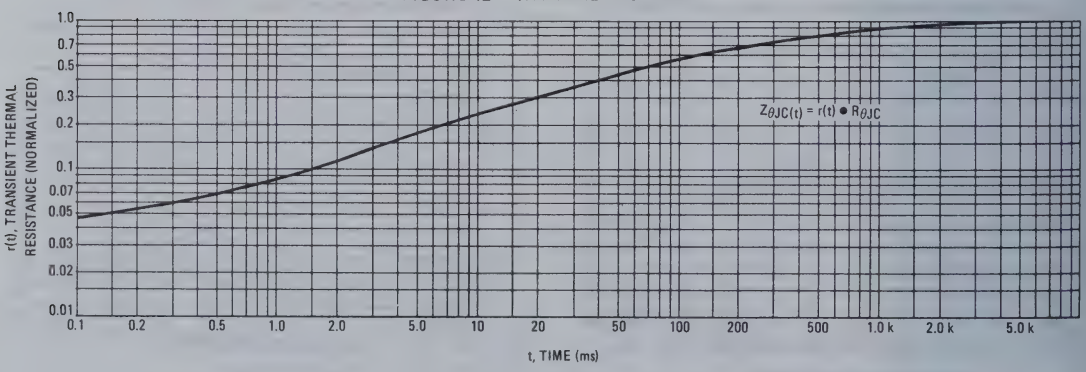


FIGURE 12 – THERMAL RESPONSE



MCR39 SERIES (SILICON)

Advance Information



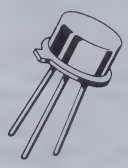
SILICON CONTROLLED RECTIFIERS

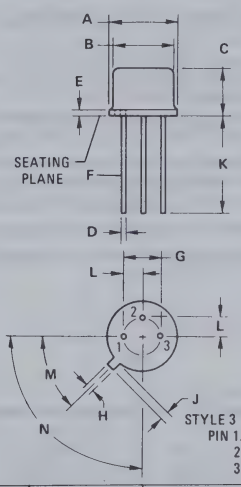
. . . designed for CD ignition and crowbar applications requiring high repetitive di/dt.

- Glass Passivated for High Reliability
- 180 Amp Repetitive di/dt
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications.

THYRISTORS

7 AMPERES RMS
50-600 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.890	9.400	0.350	0.370
B	8.000	8.510	0.315	0.335
C	6.100	6.600	0.240	0.260
D	0.406	0.483	0.016	0.019
E	0.229	3.180	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.830	5.330	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.020	0.029	0.040
K	12.700	–	0.500	–
L	2.540 TP		0.100 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

CASE 79
TO-39

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR39- -05	V_{RRM}	50	Volts
-20		200	
-30		300	
-40		400	
-50		500	
-60		600	
Peak Forward Current, $T_C = 125^oC$ P.W. = 10 μs, Duty Cycle = 0.1%	I_{TSM}	180	Amps
Peak Forward Gate Power — $T_A = 25^oC$	P_{GFM}	10	Watts
Average Forward Gate Power — $T_A = 25^oC$	$P_{GF(AV)}$	0.5	Watt
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-65 to +135	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Critical Rate-of-Rise of On-State Current during Turn-On Interval	di/dt	500	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	150	$^oC/W$

This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 135°C)		V_{DRM}			Volts
	MCR39-05		50	–	
	MCR39-20		200	–	
	MCR39-30		300	–	
	MCR39-40		400	–	
	MCR39-50		500	–	
	MCR39-60		600	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 135°C)		I_{DRM}	–	2.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 135°C)		I_{RRM}	–	2.0	mA
Forward "On" Voltage (Note 2) (I_{TM} = 50 A peak @ T_A = 25°C)		V_{TM}	–	3.5	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = Rated V_{DRM})	T_C = 25°C	I_{GT}	1.0	15	mA
	T_C = -40°C		–	30	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = Rated V_{DRM})	T_C = 25°C	V_{GT}	0.25	1.25	Volts
	T_C = -40°C		–	1.5	
Holding Current (Anode Voltage = 7.0 Vdc, Gate Open, T_C = 135°C)		I_H	1.0	–	mA
Turn-On Time (I_{TM} = 180 A, Rated V_{DRM}, C = 1.0 μF, 10 to 90%)		t_{on}	–	500	ns
Critical Exponential Rate of Rise (Rated V_{DRM}, Gate Open, T_C = 135°C)		dv/dt	50	–	V/μs

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 0.1 ms maximum duration, duty cycle ≤ 0.1%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

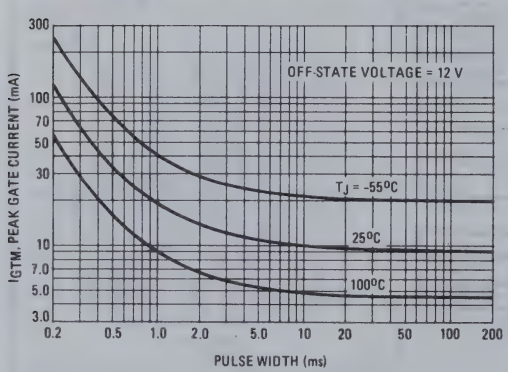
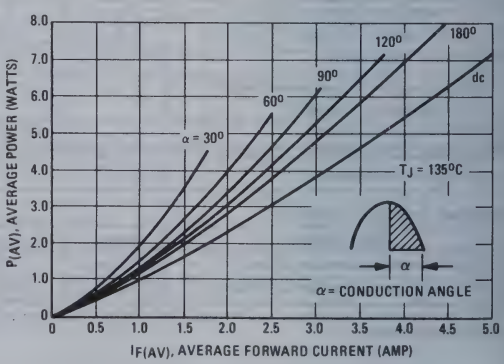


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION



MCR051 (SILICON)
thru
MCR054



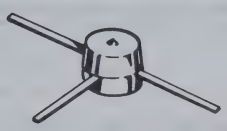
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 50 μA Maximum, T_A = 125°C
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity
- Small Size for High Density Packaging

MICRO-T PLASTIC SILICON CONTROLLED RECTIFIERS

0.25 AMPERE RMS
15 thru 100 VOLTS

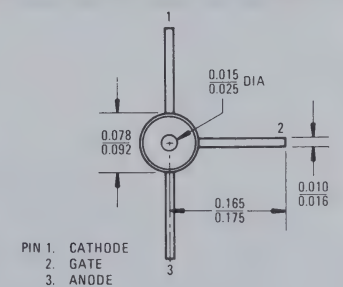


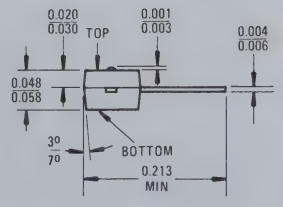
UNIT IDENTITY COLOR CODING
MCR051 — Black on Green Plastic
MCR052 — Green Plastic
MCR053 — Yellow on Green Plastic
MCR054 — Red on Green Plastic

For Handling Convenience, All Devices are Painted White on the Bottom.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR051		15	
MCR052		30	
MCR053		60	
MCR054		100	
Forward Current RMS (See Figure 3) (All Conduction Angles)	$I_{T(RMS)}$	0.25	Amp
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, T_A = 25°C (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, T_A = 25°C	P_{GM}	0.1	Watt
Average Gate Power — Forward, T_A = 25°C	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (<1/16" from case, 10 s max)	—	+230	°C





CASE 28 (8)

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)		V_{DRM}			Volts
(T_A = 125°C)	MCR051		15	–	
	MCR052		30	–	
	MCR053		60	–	
	MCR054		100	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_A = 125°C)		I_{DRM}	–	50	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_A = 125°C)		I_{RRM}	–	50	μA
Forward "On" Voltage (Note 2) (I_{TM} = 0.25 A peak @ T_A = 25°C)		V_{TM}	–	1.3	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc)	T_C = 25°C	V_{GT}	–	0.8	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	1.2	
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms)	T_C = 125°C	V_{GD}	0.1	–	
Holding Current	T_C = 25°C	I_H	–	5.0	mA
(Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = -65°C		–	10*	
Thermal Resistance, Junction to Ambient		θ_{JA}	–	500	°C/W

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – POWER DISSIPATION

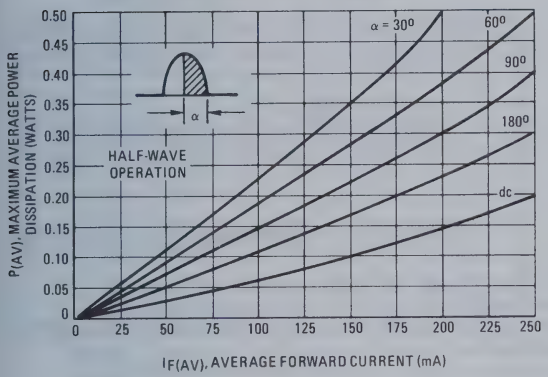


FIGURE 2 – FORWARD VOLTAGE

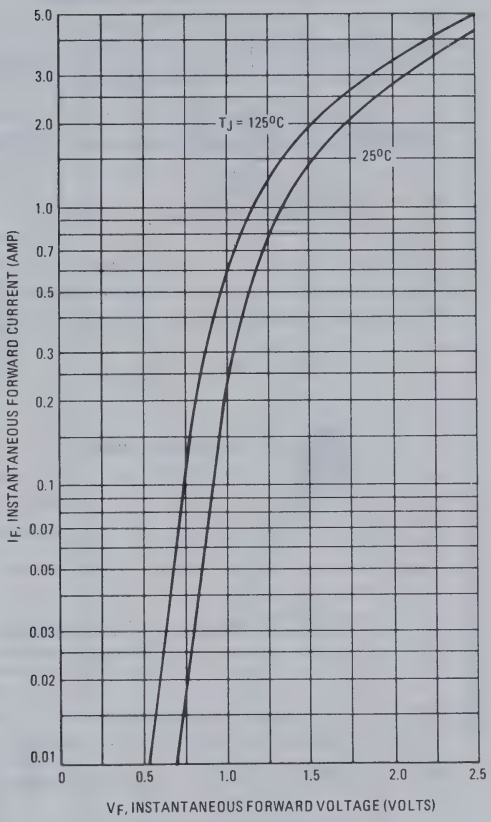
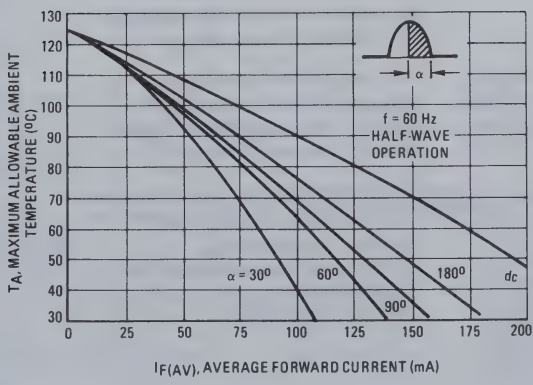


FIGURE 3 – CURRENT DERATING



TYPICAL CHARACTERISTICS

FIGURE 4 – GATE TRIGGER VOLTAGE

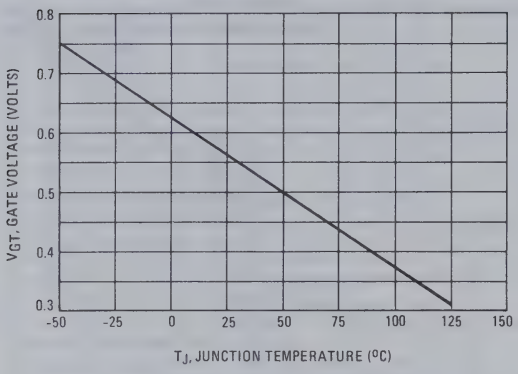


FIGURE 5 – GATE TRIGGER CURRENT

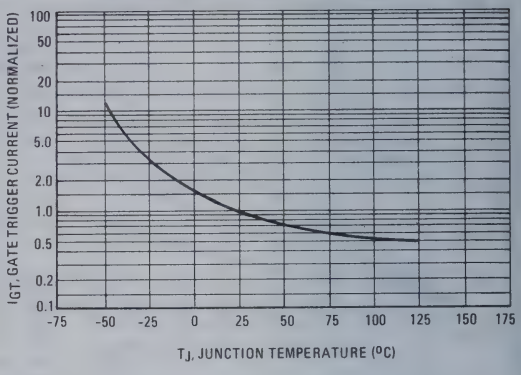


FIGURE 6 – HOLDING CURRENT

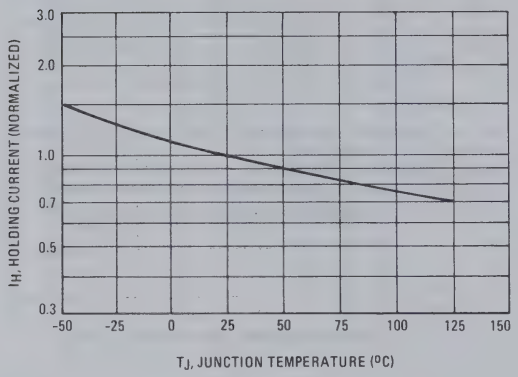
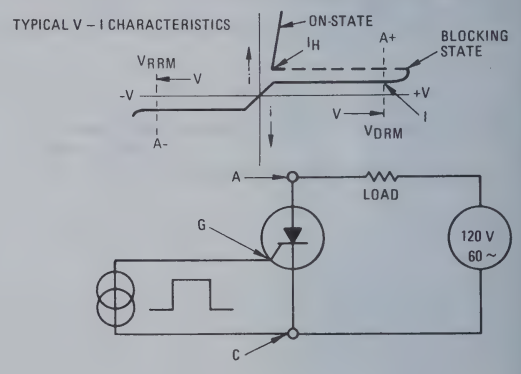


FIGURE 7 – CHARACTERISTICS AND SYMBOLS



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240 – SCR Power Control Fundamentals
AN-295 – Suppressing RFI in Thyristor Circuits
AN-422 – Testers for Thyristors and Trigger Diodes
AN-453 – Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MCR101 (SILICON)
thru
MCR104



PLASTIC THYRISTORS

. . . Annular♦ PNPN devices designed for low cost, high volume consumer applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 100 μA Maximum, T_C = 85°C
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity

PLASTIC SILICON CONTROLLED RECTIFIERS

0.8 AMPERE RMS
15 thru 100 VOLTS

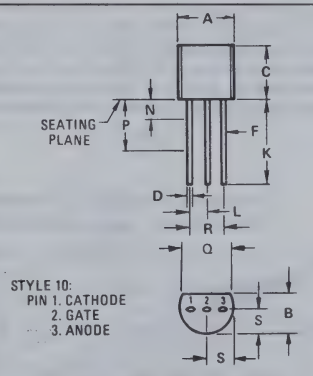


MAXIMUM RATINGS(1)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR101 MCR102 MCR103 MCR104	V_{RRM}	 15 30 60 100	Volts
Forward Current RMS (See Figures 1 & 2) (All Conduction Angles)	$I_{T(RMS)}$	0.8	Amp
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, T_A = 25°C (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, T_A = 25°C	P_{GM}	0.1	Watt
Average Gate Power — Forward, T_A = 25°C	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +85	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (<1/16" from case, 10 s max)	—	+230	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

♦Annular Semiconductor Patented by Motorola Inc.

(1) Temperature reference point for all case temperature is center of flat portion of package.
(T_C = +85°C unless otherwise noted.)

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)		V_{DRM}			Volts
(T_C = 85°C)	MCR101		15	–	
	MCR102		30	–	
	MCR103		60	–	
	MCR104		100	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 85°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 85°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2) (I_{TM} = 1.0 A peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	V_{GT}	–	0.8	Volts
	T_C = -65°C		–	1.2	
	T_C = 85°C	V_{GD}	0.1	–	
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C	I_H	–	5.0	mA
	T_C = -65°C		–	10	

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

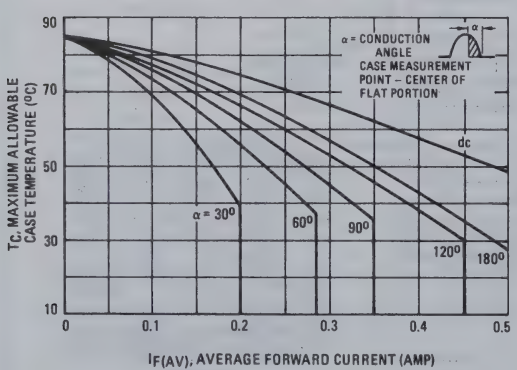
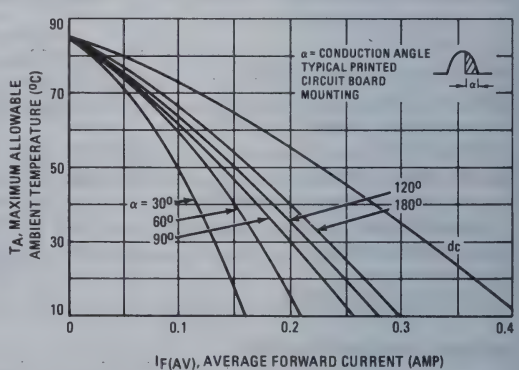


FIGURE 2 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)



MCR106-1 (SILICON)
thru
MCR106-4
MCR106-6, MCR106-8



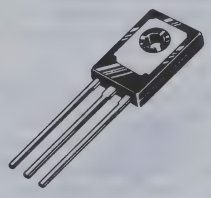
SILICON CONTROLLED RECTIFIERS

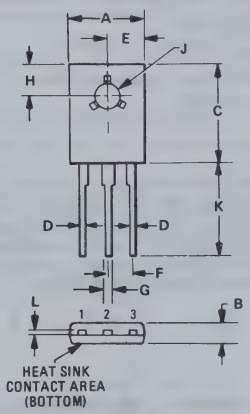
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- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability.

THYRISTORS

4.0 AMPERES RMS
30 thru 600 VOLTS





Pin 1. Cathode
2. Anode
3. Gate

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.860	8.380	0.270	0.330
B	1.770	3.300	0.070	0.130
C	9.910	11.430	0.390	0.450
D	0.508	0.660	0.020	0.026
E	3.810 NOM		0.150 NOM	
F	2.290 TP		0.090 TP	
G	0.635	0.889	0.025	0.035
H	3.300	4.450	0.130	0.175
J	2.910	3.000	0.115	0.118
K	15.110	16.650	0.595	0.655
L	0.381	0.635	0.015	0.025

CASE 77-02

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1)	MCR106-1	V_{RRM}	30	Volts
	-2		60	
	-3		100	
	-4		200	
	-6		400	
	-8		600	
RMS Forward Current (All Conduction Angles)		$I_{T(RMS)}$	4.0	Amp
Average Forward Current $T_C = 93^oC$ $T_A = 30^oC$		$I_{T(AV)}$	2.55 0.68	Amp
Peak Non-Repetitive Surge Current (1/2 cycle, 60 Hz, $T_J = -40$ to $+110^oC$)		I_{TSM}	25	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+110^oC$, t = 1.0 to 8.3 ms)		I^2t	2.6	A^2s
Peak Gate Power		P_{GM}	0.5	Watt
Average Gate Power		$P_{G(AV)}$	0.1	Watt
Peak Forward Gate Current		I_{GM}	0.2	Amp
Peak Reverse Gate Voltage		V_{RGM}	6.0	Volts
Operating Junction Temperature Range		T_J	-40 to +110	^oC
Storage Temperature Range		T_{stg}	-40 to +150	^oC
Mounting Torque (Note 2)		—	6.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	75	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms.)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C, Note 1)	MCR106-1	V_{DRM}	30	–	–	Volts
	-2		60	–	–	
	-3		100	–	–	
	-4		200	–	–	
	-6		400	–	–	
	-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 110°C)		I_{DRM}	–	–	200	μA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)		I_{RRM}	–	–	200	μA
Forward "On" Voltage (I_{TM} = 4.0 A Peak)		V_{TM}	–	–	2.0	Volts
Gate Trigger Current (Continuous dc)		I_{GT}				μA
(V_{AK} = 7.0 Vdc, R_L = 100 ohms)			–	–	200	
(V_{AK} = 7.0 Vdc, R_L = 100 ohms, T_C = -40°C)			–	–	500	
Gate Trigger Voltage (Continuous dc) (V_{AK} = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		V_{GT}	–	–	1.0	Volts
Gate Non-Trigger Voltage (V_{AK} = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)		V_{GD}	0.2	–	–	Volts
Holding Current (V_{AK} = 7.0 Vdc, T_C = 25°C)		I_H	–	–	5.0	mA
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/μs

NOTES:

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common. (See AN-290 B)

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

CURRENT DERATING

FIGURE 1 – MAXIMUM CASE TEMPERATURE

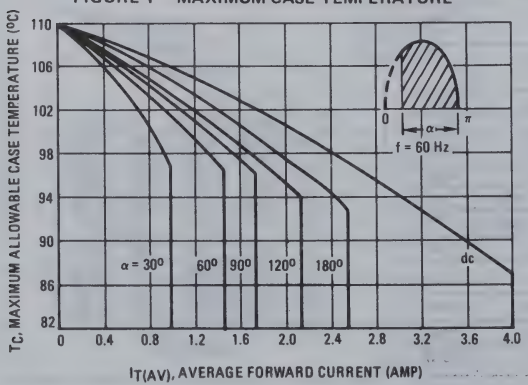
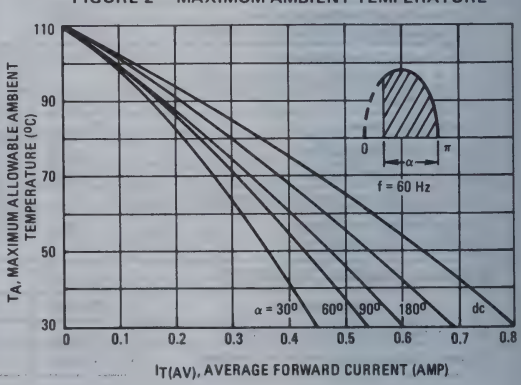


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



MCR107-1 thru MCR107-8 (SILICON)



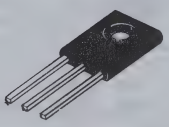
PLASTIC THYRISTORS
(PLASTIC SILICON CONTROLLED RECTIFIERS)

. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability

PLASTIC SILICON CONTROLLED RECTIFIERS

4.0 AMPERES RMS
30 thru 600 VOLTS

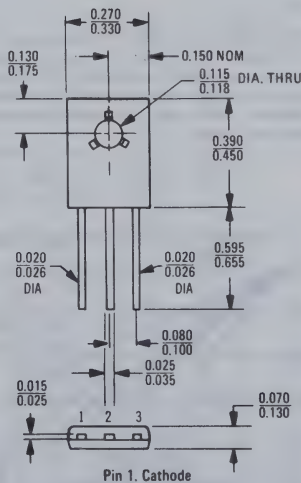


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR107 -1	V_{RRM}	30	Volts
-2		60	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
-8		600	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (½ cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	25	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C) t = 1.0 to 8.3 ms)	I^2t	2.6	A^2s
Peak Gate Power - Forward	P_{GFM}	0.5	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current - Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage - Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Mounting Torque (4-40) (Note 2)	—	8.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	75	°C/W



Pin 1. Cathode
2. Anode
3. Gate

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristics	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) (Note 1) MCR107-1	V_{DRM}	30	–	–	Volts
-2		60	–	–	
-3		100	–	–	
-4		200	–	–	
-5		300	–	–	
-6		400	–	–	
-7		500	–	–	
-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 110°C)	I_{DRM}	–	–	200	μA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)	I_{RRM}	–	–	200	μA
Forward "On" Voltage (I_{TM} = 4.0 A Peak)	V_{TM}	–	–	2.0	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	I_{GT}	–	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	V_{GT}	–	–	1.5	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc, T_C = 25°C)	I_H	–	–	20	mA
Forward Voltage Application Rate (T_J = 110°C)	dv/dt	–	10	–	V/μs

(1) Does not include current through R_{GK} resistor.

NOTES:

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.
For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C.

CURRENT DERATING DATA

FIGURE 1 – MAXIMUM CASE TEMPERATURE

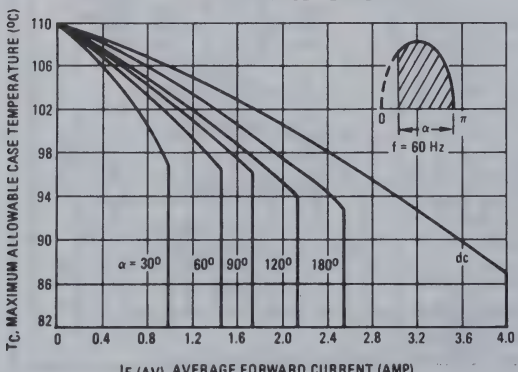
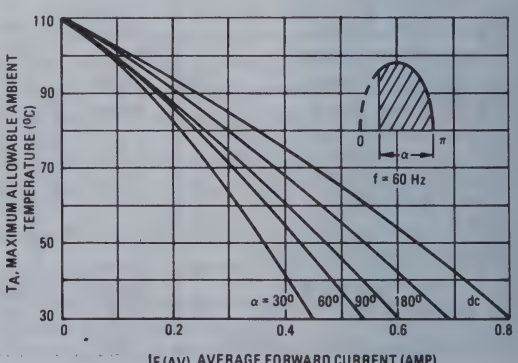


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



MCR115 (SILICON)
MCR120



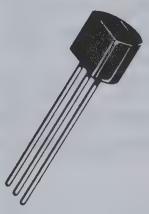
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for high volume consumer applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 100 μA Maximum, T_C = 110°C
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity

PLASTIC SILICON CONTROLLED RECTIFIERS

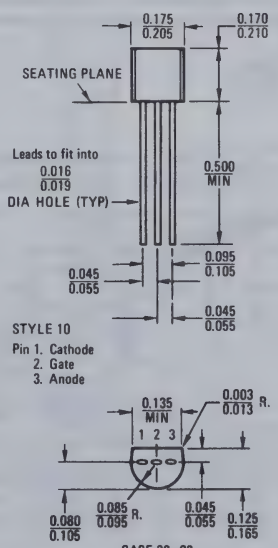
0.8 AMPERE RMS
100 and 200 VOLTS



MAXIMUM RATINGS(1)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR115 MCR120	V_{RRM}	 150 200	Volts
Forward Current RMS (See Figures 1 & 2) (All Conduction Angles)	$I_{T(RMS)}$	0.8	Amp
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, T_A = 25°C (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, T_A = 25°C	P_{GM}	0.1	Watt
Average Gate Power — Forward, T_A = 25°C	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	5.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +110	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (<1/16" from case, 10 s max)	—	+230	°C

(1) Temperature reference point for all case temperatures in center of flat portion of package. (T_C = +110°C unless otherwise noted.)



To convert inches to millimeters multiply by 25.4.

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 110°C)	MCR115	V_{DRM}	150	–	Volts
	MCR120		200	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 110°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 110°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2) (I_{TM} = 1.0 A peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc)	T_C = 25°C	V_{GT}	–	0.8	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	1.2	
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms)	T_C = 110°C	V_{GD}	0.1	–	
Holding Current	T_C = 25°C	I_H	–	5.0	mA
(Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = -65°C		–	10	
Thermal Resistance, Junction to Case		θ_{JC}	–	75	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	200	°C/W

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

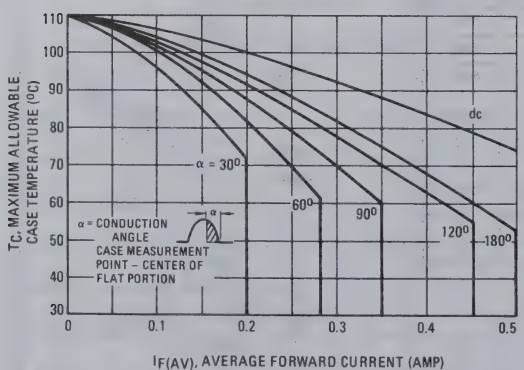
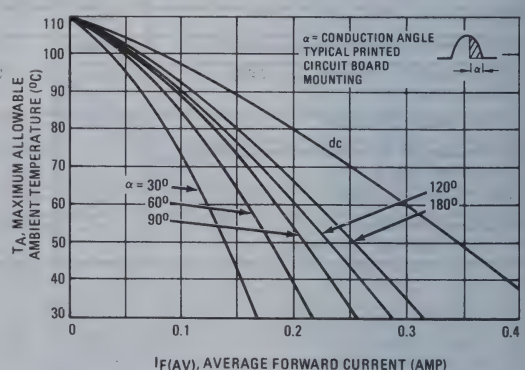


FIGURE 2 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)



MCR154, MCR155 (SILICON)
MCR156, MCR157

THYRISTORS

SILICON CONTROLLED RECTIFIERS

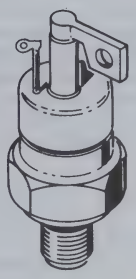
. . . designed for high frequency power switching applications such as inverters, choppers, transmitters, induction heaters, cycloconverters and high frequency lighting.

- High Voltage Application Rate — dv/dt = 200 Volts/μs (Min), MCR154, 156
- Fast Turn-Off Time — t_q = 10 μs (Max), MCR154, MCR156

THYRISTORS
PNPN
110 AMPERES RMS
100 thru 600 VOLTS



MCR154, MCR155
SERIES
CASE 219
TO-94



MCR156, MCR157
SERIES
CASE 246
TO-83

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Voltage (T_J = +125°C)		V_{DRM} (1) and		Volts
MCR154, 155, 156, 157	-10	V_{RRM}(1)	100	
	-20		200	
	-30		300	
	-40		400	
	-50		500	
	-60		600	
Non-Repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)		V_{RSM}		Volts
MCR154, 155, 156, 157	-10		200	
	-20		300	
	-30		400	
	-40		500	
	-50		600	
	-60		650	
Average On-State Current (T_C = 65°C, 180 Conduction Angle)		$I_{T(AV)}$	70	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = 40 to +125°C)		I_{TSM}	1800	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms)	I^2t	9,500	A^2s
	(t = 8.3 ms)		13,000	
Peak Gate Power		P_{GM}	15	Watts
Average Gate Power		$P_{G(AV)}$	3.0	Watt
Peak Forward Gate Current		I_{GM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (2)		—	150 175	in.lb. Kg — cm

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.3	°C/W

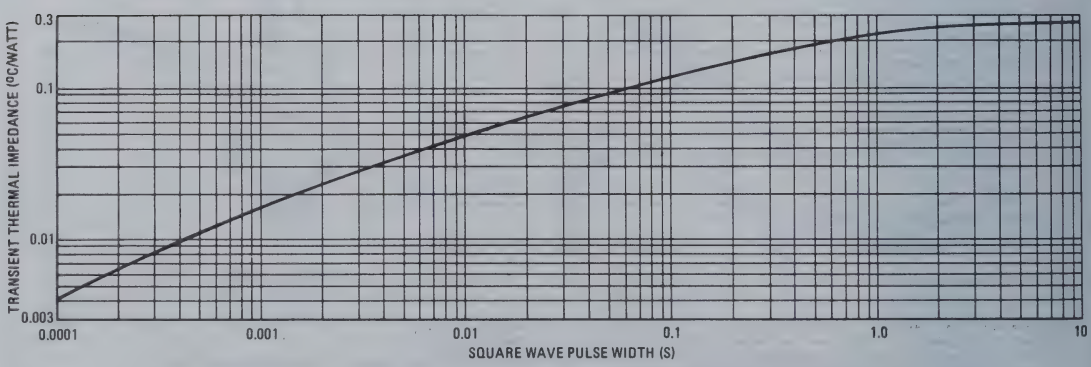
(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)		I_{DRM}	–	–	10	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)		I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 500 A Peak, Duty Cycle = 0.01%)		V_{TM}	–	–	3.0	Volts
Gate Trigger Current (Anode Voltage = 6 V, R_L = 3.0 ohms, $t_p \geq 20$ μs)	T_J = 25°C T_J = -40°C T_J = +125°C	I_{GT}	– – –	50 100 30	150 200 120	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 ohms, T_J = -40°C) (V_{DRM} = Rated, R_L = 1000 ohms, T_J = +125°C)		V_{GT}	– 0.25	– –	3.0 –	Volts
Holding Current (Anode Voltage = 24 V, Gate Open, Initiating Current = 2.0 A)		I_H	–	30	200	mA
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); V_{DRM} = Rated; T_J = +125°C; di_R/dt = 5.0 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 50 A; Duty Cycle ≤ 0.01%; Gate Bias during Turn-Off Interval = 0 V, 100 ohms; Rate of Rise of Reapplied Forward Blocking Voltage = 20 V/μs Linear)	MCR154, 156 MCR155, 157	t_q	– –	– –	10 20	μs
Critical Exponential Rate of Rise of Forward Blocking Voltage (V_{DRM} = Rated, T_J = 125°C, Gate Open)	MCR154, 156 MCR155, 157	dv/dt	200 100	– –	– –	V/μs

FIGURE 1 – THERMAL RESPONSE



FORWARD POWER DISSIPATION

FIGURE 2 – SQUARE WAVE

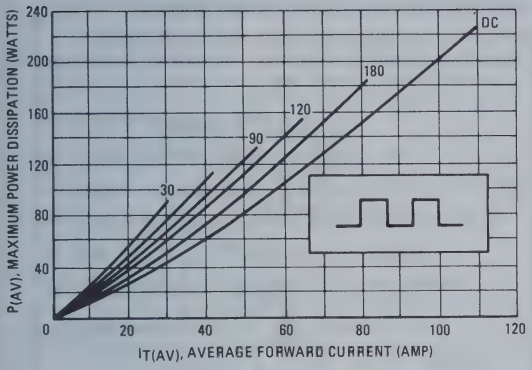
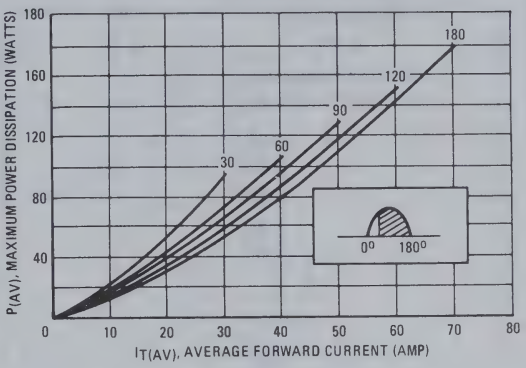


FIGURE 3 – SINE WAVE



CURRENT DERATING

FIGURE 4 – FORWARD CONDUCTION CHARACTERISTICS

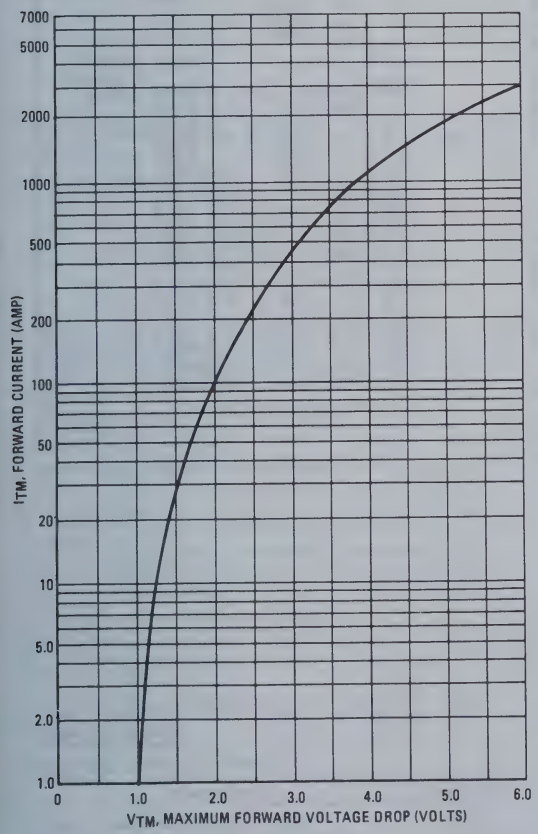


FIGURE 5 – SQUARE WAVE

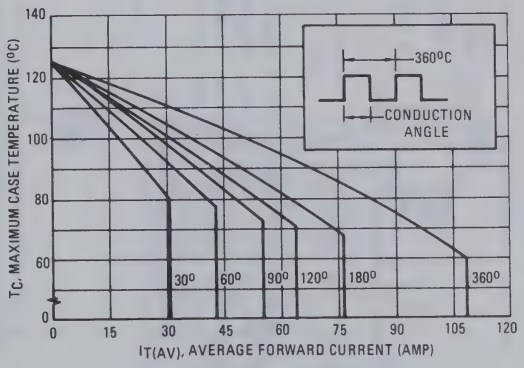
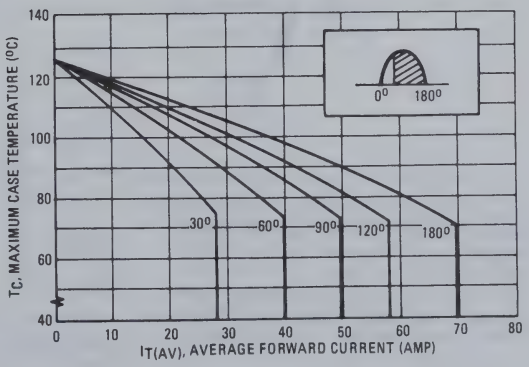
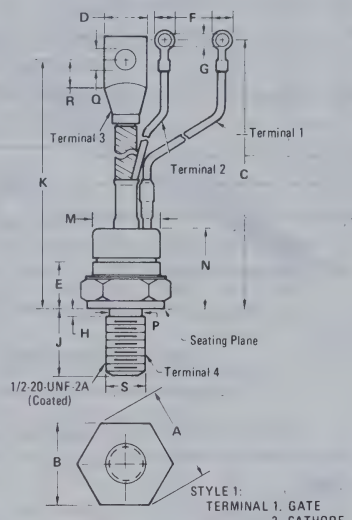


FIGURE 6 – SINE WAVE

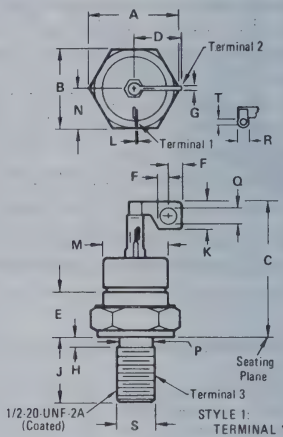




DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	6.850	7.500	174.000	190.500
D	0.437	0.650	11.100	16.500
E	0.170	0.500	4.400	12.700
F	0.215	0.300	5.490	7.620
G	0.140	0.150	3.560	3.810
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	5.775	6.265	146.700	159.100
M	–	1.031	–	26.180
N	–	2.500	–	63.500
P	0.425	0.499	10.800	12.670
Q	0.260	0.310	6.610	7.870
R	0.250	–	6.350	–
S	0.4619	0.4675	11.733	11.874

All JEDEC dimensions and notes apply

CASE 219
TO-94



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	–	1.810	–	45.970
D	–	0.650	–	16.510
E	0.170	0.500	4.400	12.700
F	0.180	–	4.580	–
G	0.060	0.115	1.530	2.920
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	0.360	0.470	9.200	11.900
L	0.012	0.050	0.310	1.270
M	–	1.031	–	26.180
N	–	0.575	–	14.600
P	0.425	0.499	10.800	12.670
Q	0.180	0.260	4.580	6.600
R	0.115	0.160	2.930	4.060
S	0.4619	0.4675	11.733	11.874
T	0.060	0.080	1.530	2.030

All JEDEC dimensions and notes apply

CASE 246
TO-83

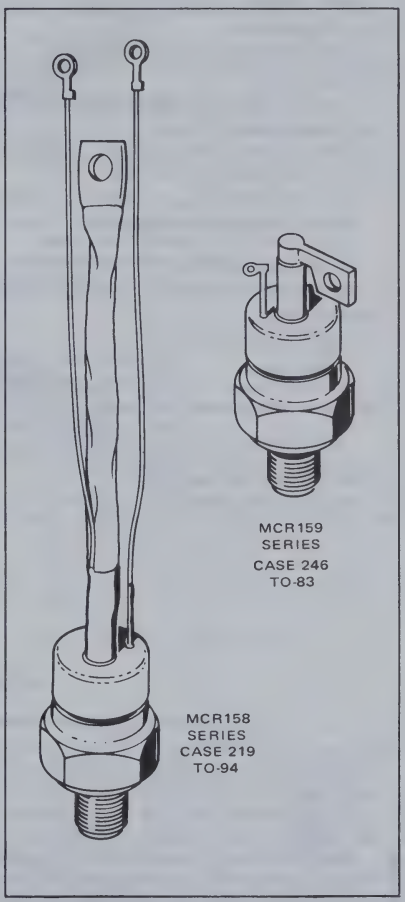
MCR158 (SILICON)
MCR159

INTEGRATED GATE THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for high frequency applications which require high di/dt such as inverters, choppers, transmitters, induction heaters, crowbars, cycloconverters and high frequency lighting.

- 10 kHz Sine Wave Operation
- 5 kHz Rectangular Waveform Operation
- Critical Rate-of-Rise of On-State Current – di/dt = 800 Amp/μs (Max)*
- Critical Exponential Rate – dv/dt = 200 V/μs (Min)
- Low Switching Losses at High Frequency
- Integrated Gate Permits Soft-Fire Gate Control

INTEGRATED GATE THYRISTORS
PNPN
110 AMPERES RMS
500 thru 1200 VOLTS



MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak off-State Voltage (T_J = +125°C) MCR158,159	– 50	$V_{DRM(1)}$	500	Volts
	– 60		600	
	– 70		700	
	– 80	V_{RRM}	800	
	– 90		900	
	– 100		1000	
	– 110		1100	
	– 120		1200	
Non-Repetitive Peak Reverse Block Voltage ($t \leq 5.0$ ms) MCR158,159	– 50	V_{RSM}	600	Volts
	– 60		720	
	– 70		840	
	– 80		960	
	– 90		1080	
	– 100		1200	
	– 110		1300	
	– 120		1400	
Average Forward Current, T_C = 65°C 180°C Conducted Angle		$I_{T(AV)}$	70	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = –40 to +125°C)		I_{TSM}	1600	Amp
Circuit Fusing Considerations (T_J = –40 to +125°C)	(t = 1.5 ms)	I^2t	5200	A^2s
	(t = 8.3 ms)		10,500	
Peak Gate Power		P_{GFM}	15	Watts
Average Gate Power		$P_{GF(AV)}$	3.0	Watt
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (2)		–	150 175	in.lb. Kg-cm
Critical Rate-of-Rise of On-State Current during Turn ± On Interval		di/dt	800	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.3	°C/W

*With 0.05 μF and 20 ohm snubber circuit.

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	10	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 500 A Peak, Duty Cycle ≤ 0.01%)	V_{TM}	–	–	3.0	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Circuit Commutated Turn-Off Time V_R = 50 V (Min); V_{DRM} = Rated; T_J = +125°C; di_R/dt = 5.0 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 150 A; Duty Cycle ≤ 0.01%; Gate Bias during Turn-Off Interval = 0 V, 100 ohms; Rate of Rise of Reapplied Forward Blocking Voltage = 20 V/μs Linear	t_q	–	–	30	μs
Turn-On Time (I_{TM} = 50 A, V_{DRM} = Rated) Gate Supply = 10 V open circuit, 20 Ohm 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Supply = 5.0 V open circuit, 5.0 Ohm 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (V_{DRM} = Rated, Gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

ALLOWABLE PEAK ON-STATE CURRENT

FIGURE 1 – SQUARE WAVE

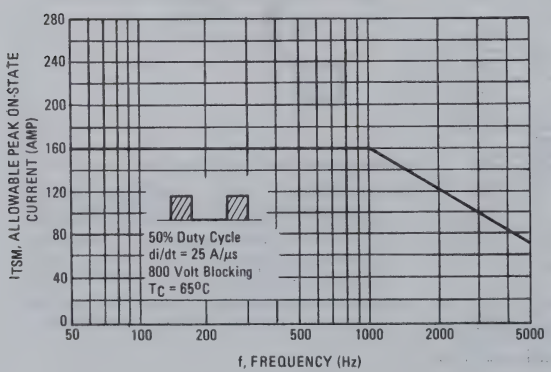
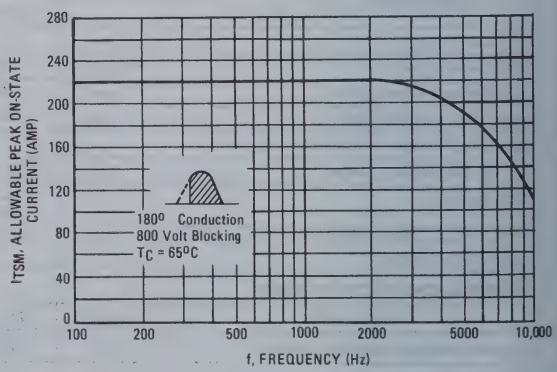


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

FIGURE 3 – SQUARE WAVE

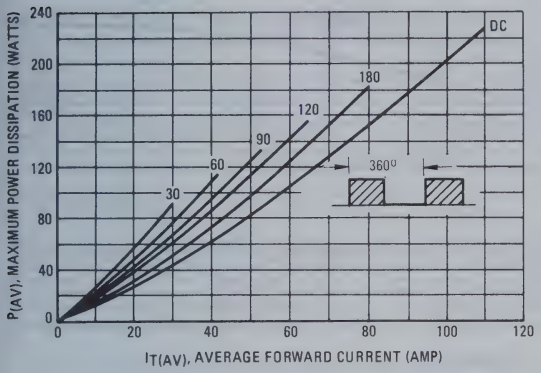
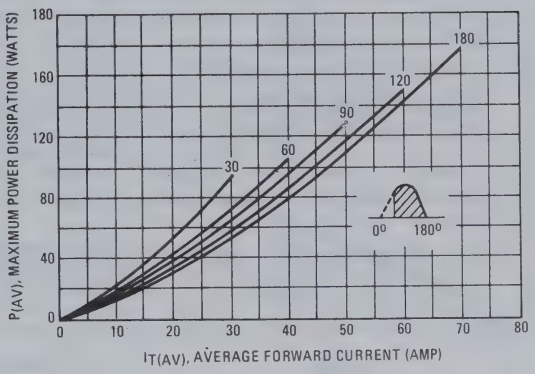


FIGURE 4 – SINE WAVE



CURRENT DERATING

FIGURE 5 – FORWARD CONDUCTION CHARACTERISTICS

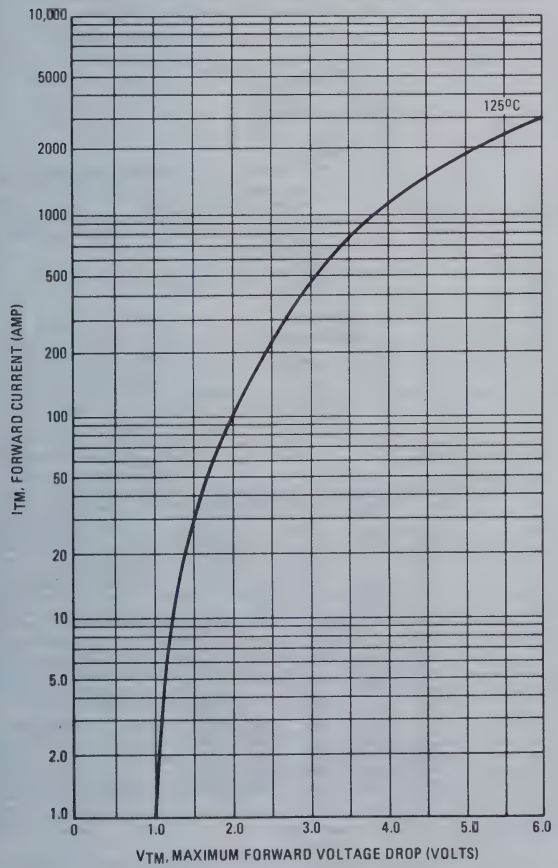


FIGURE 6 – SQUARE WAVE

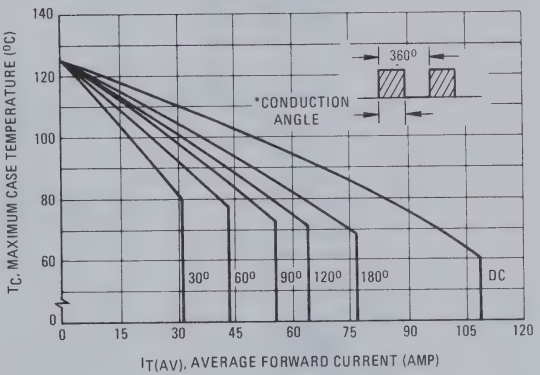


FIGURE 7 – SINE WAVE

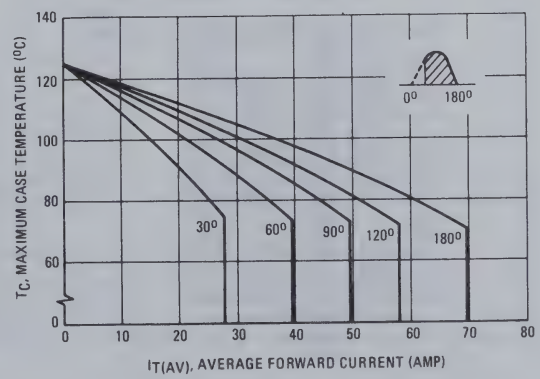
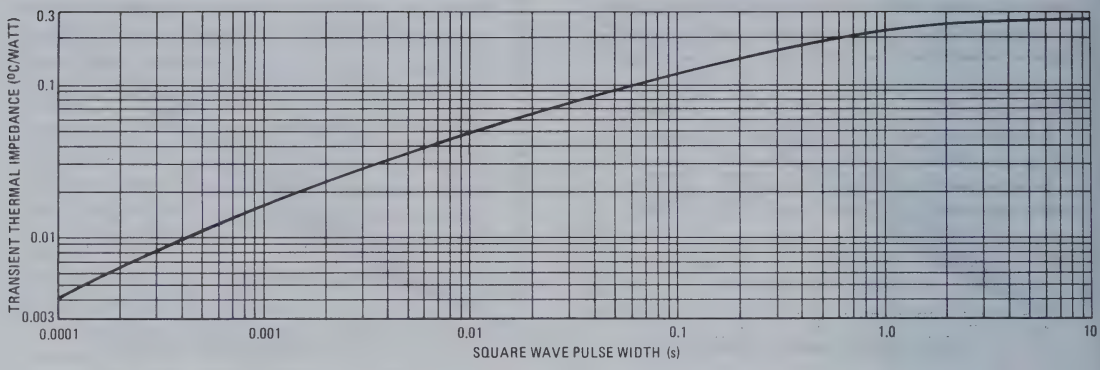
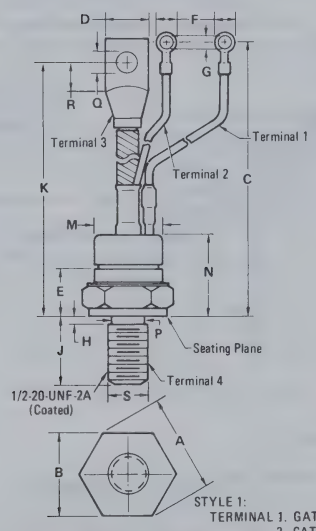


FIGURE 8 – THERMAL RESPONSE

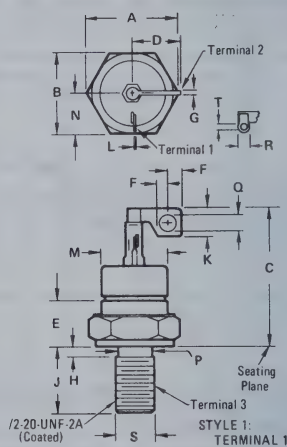




DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	6.850	7.500	174.000	190.500
D	0.437	0.650	11.100	16.500
E	0.170	0.500	4.400	12.700
F	0.215	0.300	5.490	7.620
G	0.140	0.150	3.560	3.810
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	5.775	6.265	146.700	159.100
M	–	1.031	–	26.180
N	–	2.500	–	63.500
P	0.425	0.499	10.800	12.670
Q	0.260	0.310	6.610	7.870
R	0.250	–	6.350	–
S	0.4619	0.4675	11.733	11.874

All JEDEC dimensions and notes apply

CASE 219
TO-94

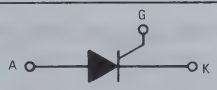


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	–	1.810	–	45.970
D	–	0.650	–	16.510
E	0.170	0.500	4.400	12.700
F	0.180	–	4.580	–
G	0.060	0.115	1.530	2.920
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	0.360	0.470	9.200	11.900
L	0.012	0.050	0.310	1.270
M	–	1.031	–	26.180
N	–	0.575	–	14.600
P	0.425	0.499	10.800	12.670
Q	0.180	0.260	4.580	6.600
R	0.115	0.160	2.930	4.060
S	0.4619	0.4675	11.733	11.874
T	0.060	0.080	1.530	2.030

All JEDEC dimensions and notes apply

CASE 246
TO-83

MCR201 (SILICON)
thru
MCR206



SILICON CONTROLLED RECTIFIERS

0.5 AMPERE RMS
15 thru 200 VOLTS

SIGNAL THYRISTORS

. . . Annular PNPN devices designed for industrial/military applications such as relay and lamp drivers, small motor controllers and drivers for larger thyristors, and in sensing and detection circuits.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 100 μA Maximum, T_C = 125°C
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity
- TO-18 Metal Package

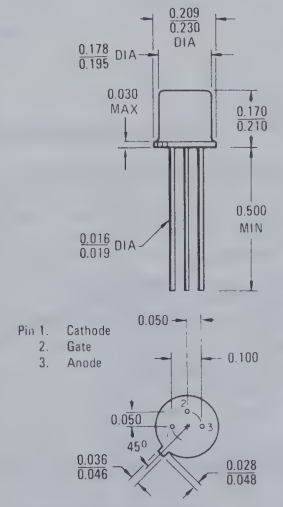


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR201 MCR202 MCR203 MCR204 MCR205 MCR206	V_{RRM}	 15 30 60 100 150 200	Volts
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	0.5	Amp
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, T_A = 25°C (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, T_A = 25°C	P_{GM}	0.1	Watt
Average Gate Power — Forward, T_A = 25°C	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-65 to +110	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	150	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	400	°C/W



All JEDEC dimensions and notes apply

Anode Connected to Case

CASE 22 (03)
(TO-18)

(1) Higher Temperature Devices Available — Consult Factory.

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)		V_{DRM}			Volts
	MCR201		15	–	
	MCR202		30	–	
	MCR203		60	–	
	MCR204		100	–	
	MCR205		150	–	
	MCR206		200	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 110°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 110°C)		I_{RRM}	–	1.5	μA
Forward "On" Voltage (Note 2) (I_{TM} = 500 mA peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3)	T_C = 25°C	I_{GT}	–	200	μA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	350	
Gate Trigger Voltage (Continuous dc)	T_C = 25°C	V_{GT}	–	0.8	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = -65°C		–	1.2	
(Anode Voltage = Rated V_{DRM})	T_C = 110°C	V_{GD}	0.1	–	
Holding Current	T_C = 25°C	I_H	–	5.0	mA
(Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = -65°C		–	10	

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≦ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – SURGE RATINGS

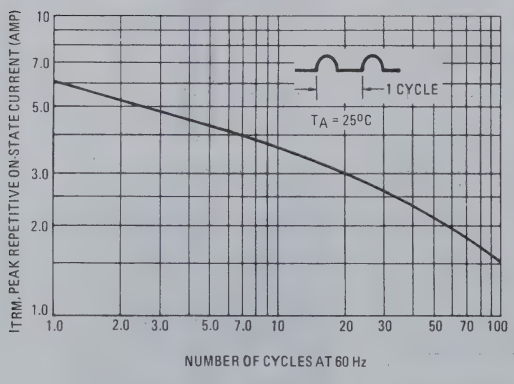


FIGURE 2 – POWER DISSIPATION

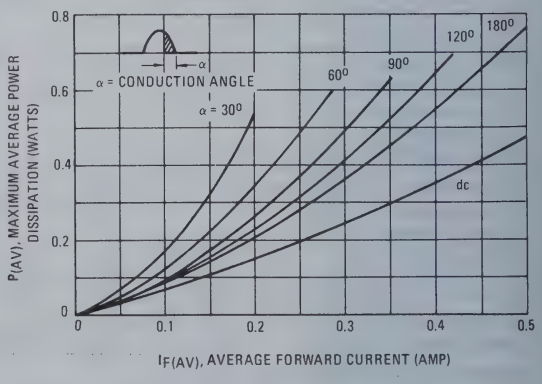


FIGURE 3 – FORWARD VOLTAGE

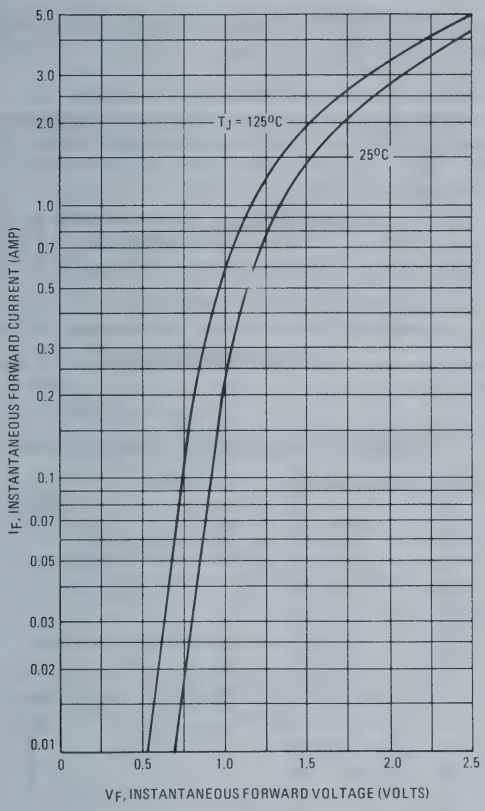


FIGURE 4 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

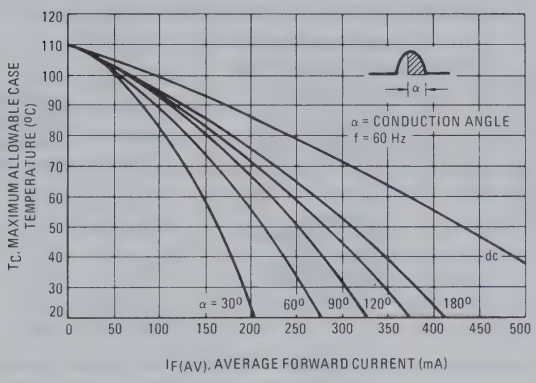


FIGURE 5 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

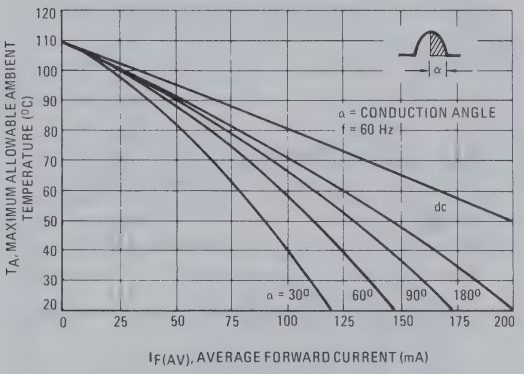
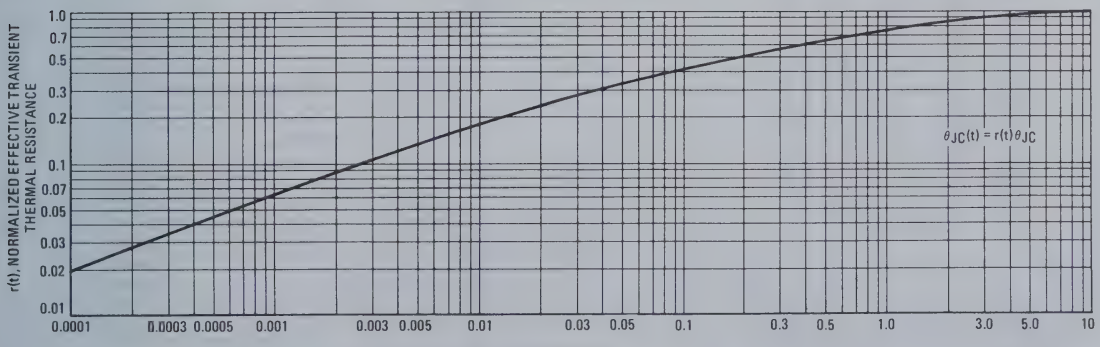


FIGURE 6 – THERMAL RESPONSE



TYPICAL CHARACTERISTICS

FIGURE 7 – GATE TRIGGER VOLTAGE

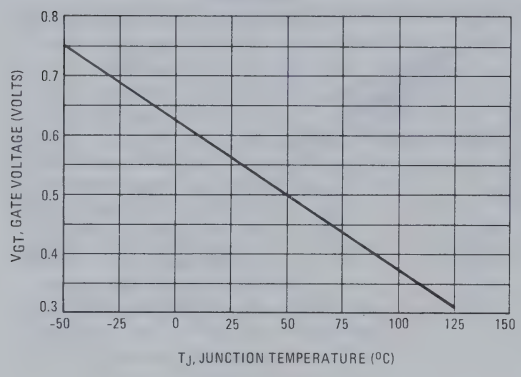


FIGURE 8 – GATE TRIGGER CURRENT

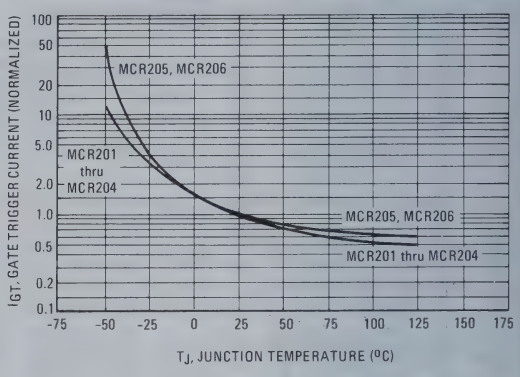


FIGURE 9 – HOLDING CURRENT

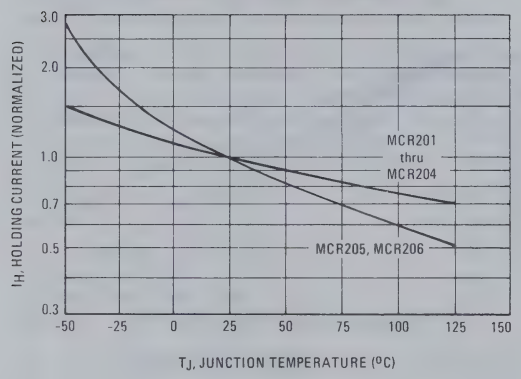
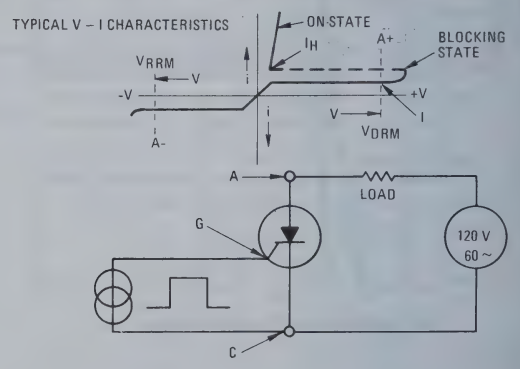


FIGURE 10 – CHARACTERISTICS AND SYMBOLS



MCR235 SERIES (SILICON)

BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Low Switching Losses at High Frequency
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 μF and 20-ohm snubber circuit

BEAM-FIRED INTEGRATED GATE THYRISTORS

235 AMPERES RMS
100 thru 1500 VOLTS

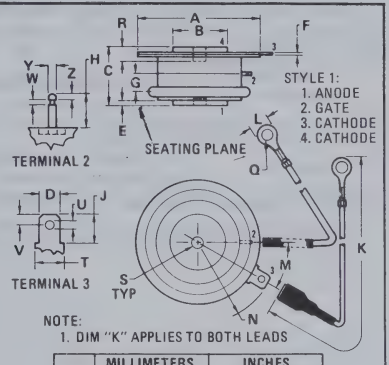


MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR235	-10	$V_{DRM(1)}$	100	Volts
	-20	V_{RRM}	200	
	-30		300	
	-40		400	
	-50		500	
	-60		600	
	-70		700	
	-80		800	
	-90		900	
	-100		1000	
	-110		1100	
	-120		1200	
	-130		1300	
	-140		1400	
	-150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ≤ 5.0 ms) MCR235	-10	V_{RSM}	200	Volts
	-20		300	
	-30		400	
	-40		500	
	-50		600	
	-60		720	
	-70		840	
	-80		960	
	-90		1080	
	-100		1200	
	-110		1300	
	-120		1450	
	-130		1550	
	-140		1650	
	-150		1800	
Average Forward Current, T_C = 75°C (180° Conduction Angle)		$I_{T(AV)}$	150	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	1800	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms)	I^2t	9500	A^2s
	(t = 8.3 ms)		13,000	
Peak Forward Gate Power		P_{GFM}	15	Watts
Average Forward Gate Power		$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		—	1000	lbs
Critical Rate-of-Rise of On-State Current during Turn-On Interval (Non-Repetitive Rating)		di/dt	1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	°C/W



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	—	0.300	—
H	3.94	—	0.155	—
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	—	7.62	—	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 220 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	–	–	1.6	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse { 10 V open circuit, 20 Ohm Source; 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Pulse { 5.0 V open circuit, 5.0 Ohm Source; 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (V_{DRM} = Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

CURRENT DERATING
(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

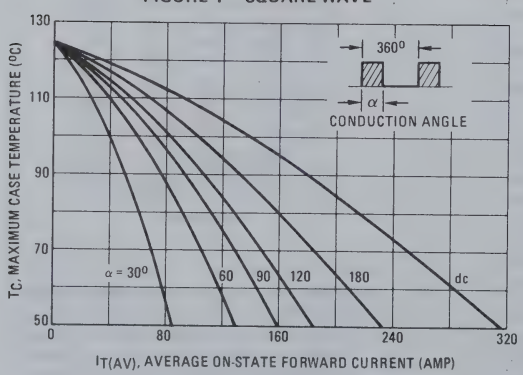
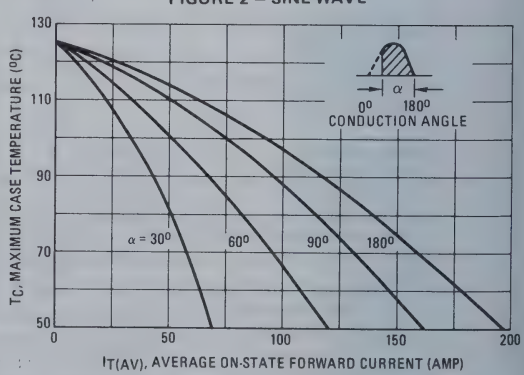


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

(f = 50 to 400 Hz)

FIGURE 3 – SQUARE WAVE

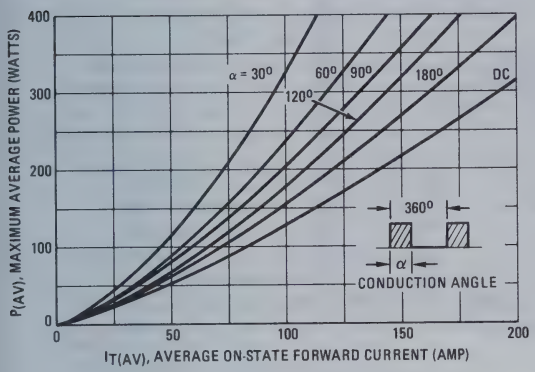


FIGURE 4 – SINE WAVE

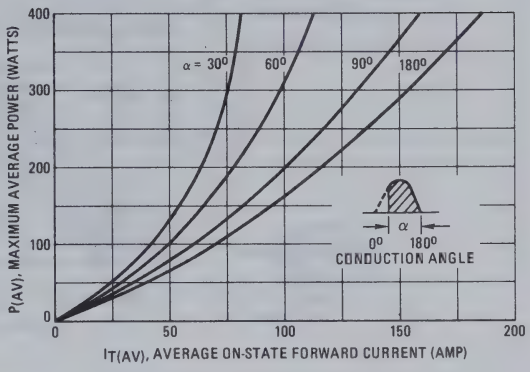


FIGURE 5 – MAXIMUM ON-STATE CHARACTERISTICS

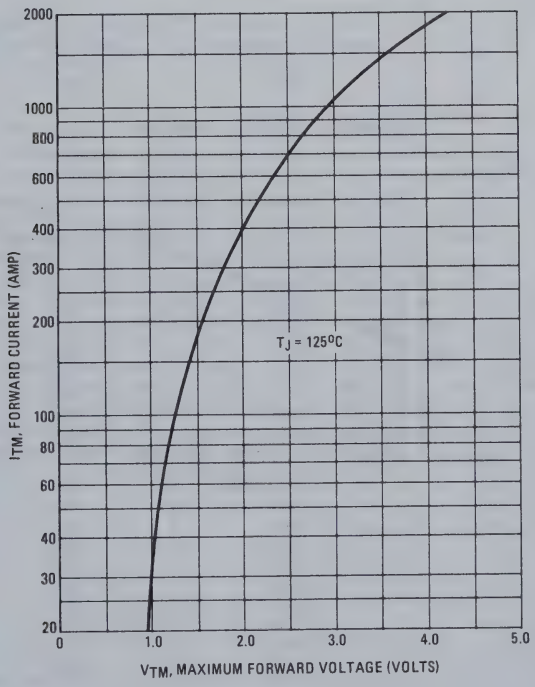


FIGURE 6 – TRIGGERING CHARACTERISTICS

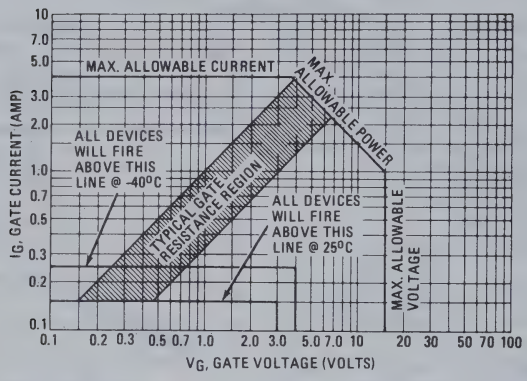
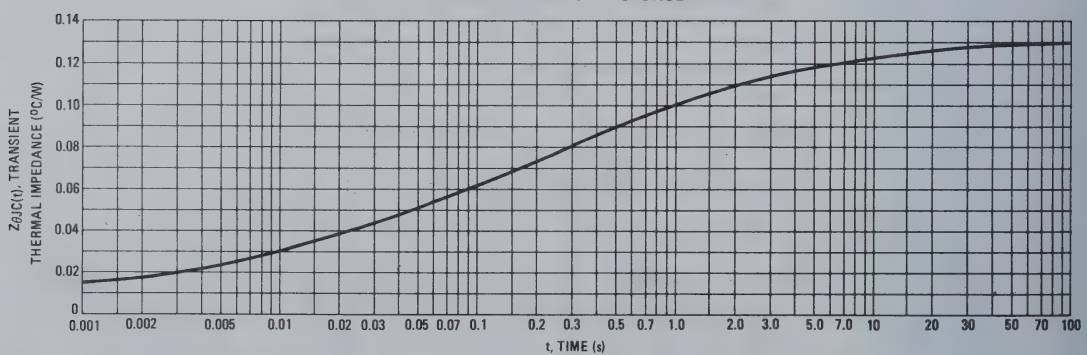


FIGURE 7 – THERMAL RESPONSE



MCR235A SERIES (SILICON)
MCR235B SERIES
MCR235C SERIES

Advance Information

BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

... designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses — @ 3.0 μs with 30 μs Pulse, Ip = 100 A
  MCR235A Series = 3.0 Volts
  MCR235B Series = 6.0 Volts
  MCR235C Series = 6.0 Volts
- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time — 10 to 20 μs

*With 0.05 μF and 20 ohm snubber circuit.

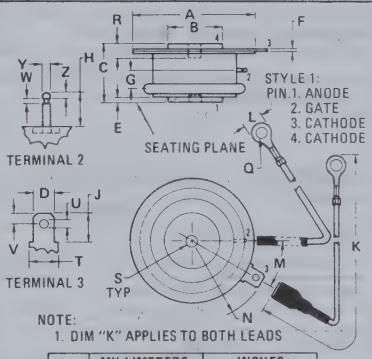
BEAM-FIRED INTEGRATED GATE THYRISTORS

235 AMPERES RMS



MAXIMUM RATINGS

Device Type		Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 10 μs Max			
MCR235A	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
Turn-Off Time = 15 μs Max			
MCR235B	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
Turn-Off Time = 20 μs Max			
MCR235C	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	–	0.300	–
H	3.94	–	0.155	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180° Conduction Angle)	$I_{T(AV)}$	150	Amp
Peak Surge Current (One Cycle, 60 Hz, $T_J = -40$ to $+125^oC$)	I_{TSM}	1600	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+125^oC$, t = 1.5 – 8.3 ms)	I^2t	10,500	A^2s
Peak Forward Gate Power	P_{GFM}	15	Watts
Average Forward Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC
Mounting Force	—	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current — Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

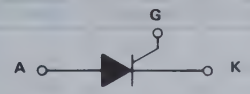
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 125^oC$)		I_{DRM}	—	—	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 125^oC$)		I_{RRM}	—	—	15	mA
Forward "On" Voltage (I_{TM} = 220 A Peak, Pulse Width = 8.3 ms, Duty Cycle = ≤1.0%, $T_J = 25^oC$)		V_{TM}	—	—	1.85	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		I_{GT}	—	—	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		V_{GT}	—	—	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)		I_H	—	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, $T_J = 125^oC$)		V_{GDM}	0.15	—	—	Volts
Circuit Commutated Turn-Off Time		t_q				μs
(V_R = 50 V (Min); Rated V_{DRM}, $T_J = +125^oC$,	MCR235A		—	—	10	
di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps;	MCR235B		—	—	15	
I_{TM} = 150 A dv/dt = 20 V/μs)	MCR235C		—	—	20	
Transient Turn-On Voltage	MCR235A	V_{TO}	—	—	5.0	Volts
(V_{DRM} = 100 V, I_{TM} = 200 A, PW = 8.0 μs,	MCR235B		—	—	8.0	
Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	MCR235C		—	—	8.0	
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, $T_J = 125^oC$)		dv/dt	200	—	—	V/μs

MCR320 SERIES (SILICON)



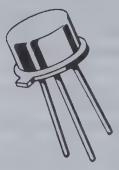
THYRISTORS

7 AMPERES RMS
50-600 VOLTS

SILICON CONTROLLED RECTIFIERS

. . . designed primarily for industrial applications. Ideally suited for capacitor-discharge ignition, systems, power switching and power control.

- Glass Passivated for High Reliability
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications
- High di/dt Capability

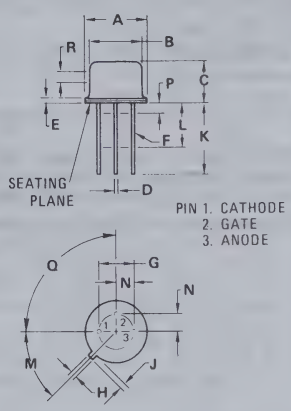


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR320 –1		25	
–2		50	
–3		100	
–4		200	
–5		300	
–6		400	
–7		500	
–8		600	
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	7.0	Amps
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	80	Amps
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Forward Peak Gate Power, $T_A = 25^oC$	P_{GM}	10	Watts
Forward Average Gate Power, $T_A = 25^oC$	$P_{G(AV)}$	0.5	Watt
Forward Peak Gate Current, $T_A = 25^oC$ (300 μs, 120 PPS)	I_{GM}	10	Amps
Reverse Peak Gate Voltage	V_{GM}	4.0	Volts
Operating Junction Temperature Range	T_J	-40 to +100	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	$^oC/W$



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

All JEDEC notes and dimensions apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1)	V_{DRM}			Volts
MCR320–1		25	–	
MCR320–2		50	–	
MCR320–3		100	–	
MCR320–4		200	–	
MCR320–5		300	–	
MCR320–6		400	–	
MCR320–7		500	–	
MCR320–8		600	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 100°C)	I_{DRM}	–	1.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 100°C)	I_{RRM}	–	1.0	mA
Forward "On" Voltage (2) (I_{TM} = 30 A peak @ T_C = 25°C)	V_{TM}	–	2.6	Volts
Gate Trigger Current (Continuous dc) (3) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	I_{GT}	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	V_{GT}	–	1.5	Volts
Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 30 Ohms, T_C = 100°C)	V_{GD}	0.1	–	Volts
Holding Current (Gate Open, T_C = 25°C)	I_H	–	20	mA

(1) Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

(2) Forward current applied for 1.0 ms maximum duration, duty cycle ≤1.0%.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

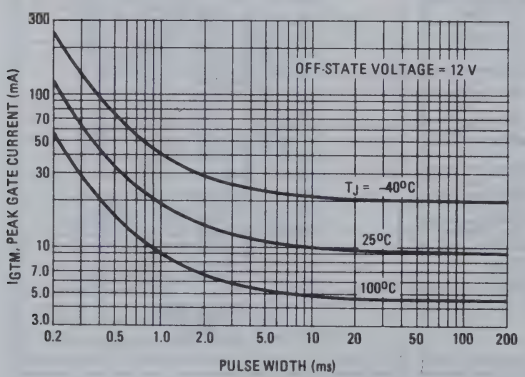


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

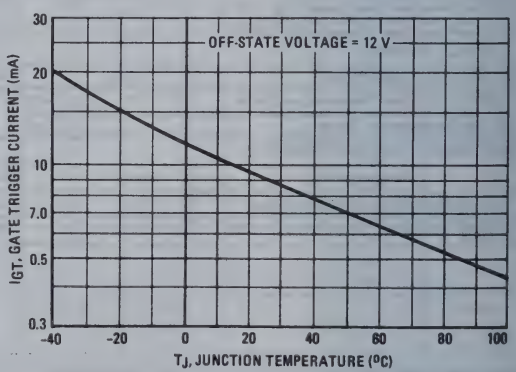


FIGURE 3 – MAXIMUM ON-STATE POWER DISSIPATION

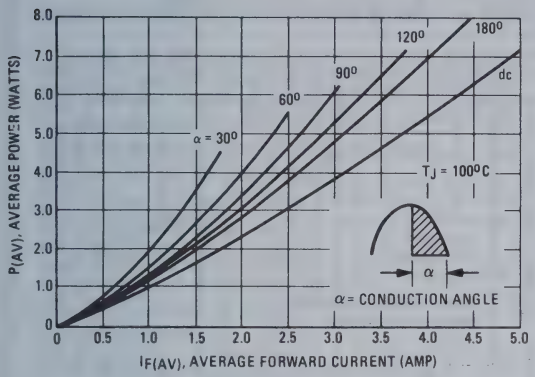


FIGURE 4 – AVERAGE CURRENT DERATING (REFERENCE. CASE TEMPERATURE)

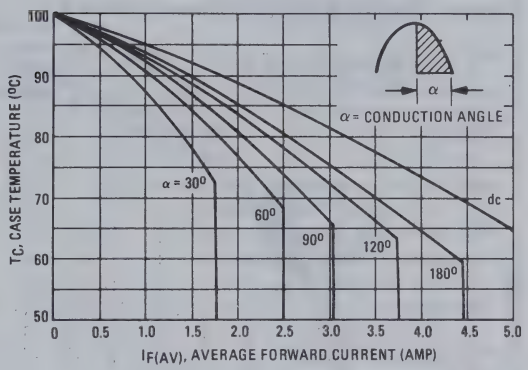


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE 4 in. sq. P.C. BOARD)

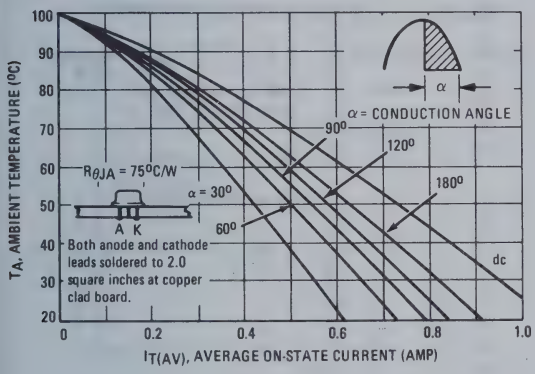


FIGURE 6 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE , TYPICAL P.C. BOARD MOUNTING)

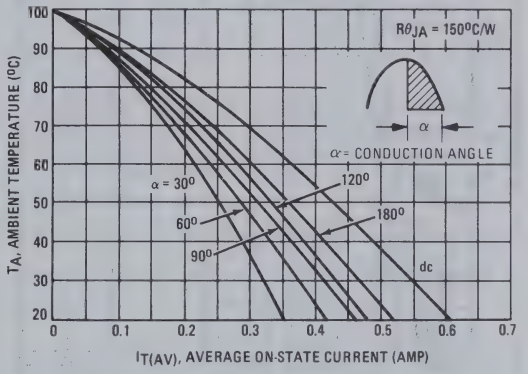


FIGURE 7 – TYPICAL GATE TRIGGER VOLTAGE

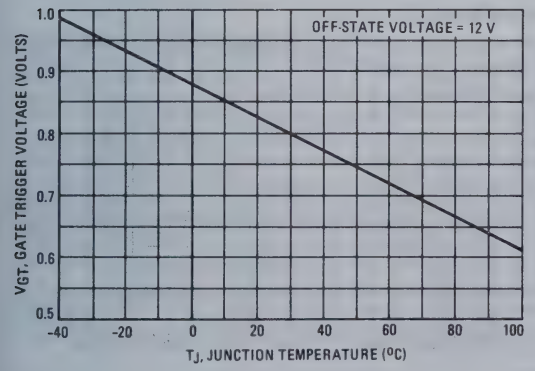


FIGURE 8 – TYPICAL HOLDING CURRENT

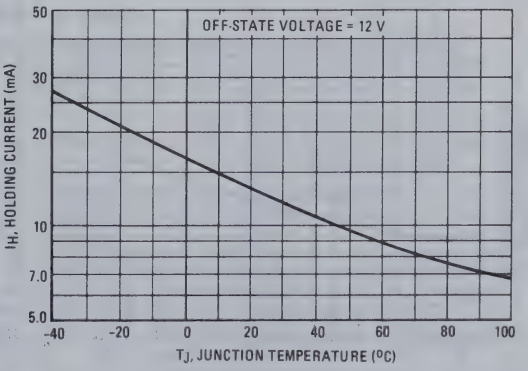


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

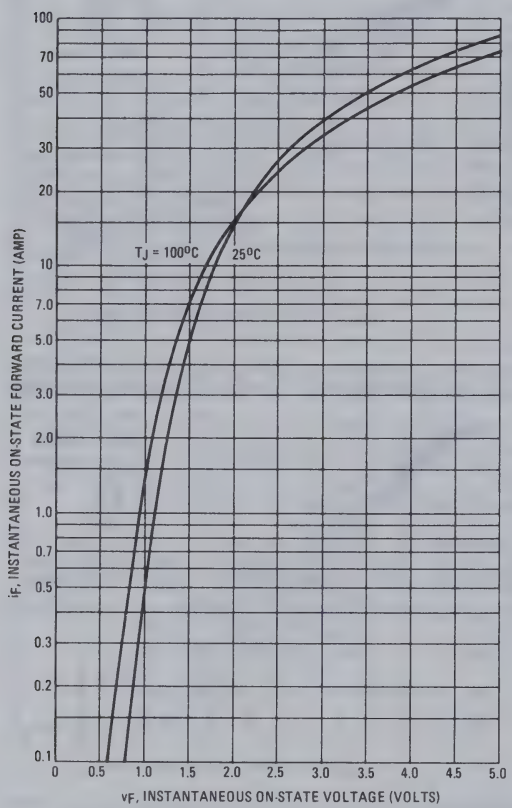


FIGURE 10 – MAXIMUM NON-REPETITIVE SURGE CURRENT

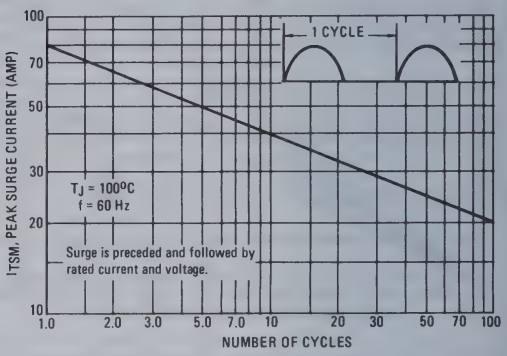


FIGURE 11 – CHARACTERISTICS AND SYMBOLS

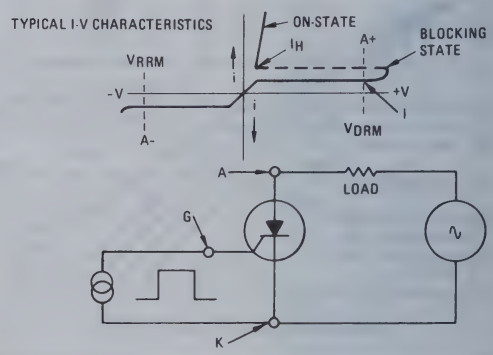
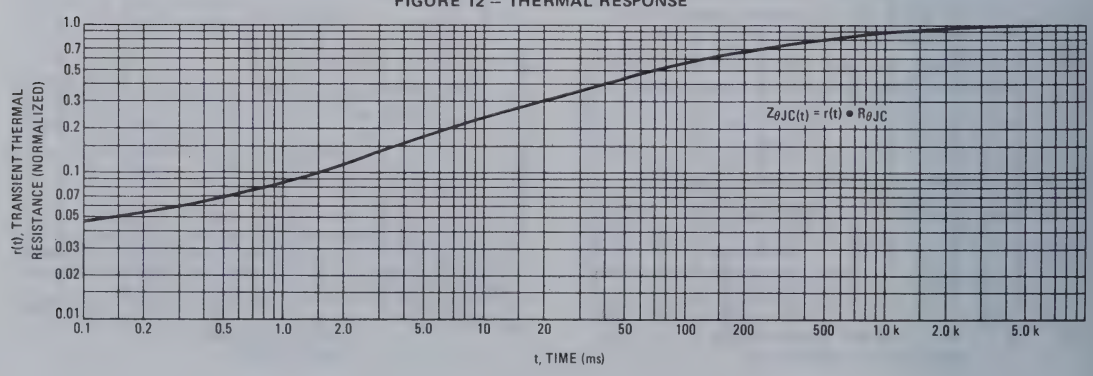


FIGURE 12 – THERMAL RESPONSE



MCR380 SERIES (SILICON)

BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

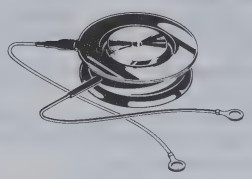
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Low Switching Losses
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 μF and 20-ohm snubber circuit.

BEAM-FIRED INTEGRATED GATE THYRISTORS

380 AMPERES RMS
100 thru 1500 VOLTS

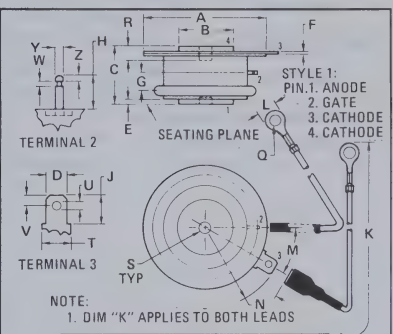


MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR380	-10	$V_{DRM(1)}$	100	Volts
	-20	V_{RRM}	200	
	-30		300	
	-40		400	
	-50		500	
	-60		600	
	-70		700	
	-80		800	
	-90		900	
	-100		1000	
	-110		1100	
	-120		1200	
	-130		1300	
	-140		1400	
	-150		1500	
Non-Repetitive Peak Reverse Block Voltage ($t \leq 5.0$ ms) MCR380	-10	V_{RSM}	200	Volts
	-20		300	
	-30		400	
	-40		500	
	-50		600	
	-60		720	
	-70		840	
	-80		960	
	-90		1080	
	-100		1200	
	-110		1300	
	-120		1450	
	-130		1550	
	-140		1650	
	-150		1800	
Average Forward Current (T_C = 72°C) (180° Conduction Angle)		$I_{T(AV)}$	250	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	3500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms)	I^2t	32,000	A^2s
	(t = 8.3 ms)		50,000	
Peak Forward Gate Power		P_{GFM}	15	Watts
Average Forward Gate Power		$P_{GF(AV)}$	3.0	Watt
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		–	1000	lbs
Critical Rate-of-Rise of On-State Current during Turn-On Interval (Non-Repetitive Rating)		di/dt	1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.095	°C/W



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	–	0.300	–
H	3.94	–	0.155	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	20	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	–	–	2.4	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse { 10 V open circuit, 20 Ohm Source; 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Pulse { 5.0 V open circuit, 5.0 Ohm Source; 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

CURRENT DERATING
(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

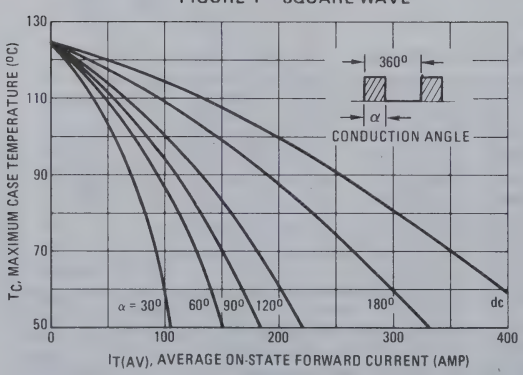
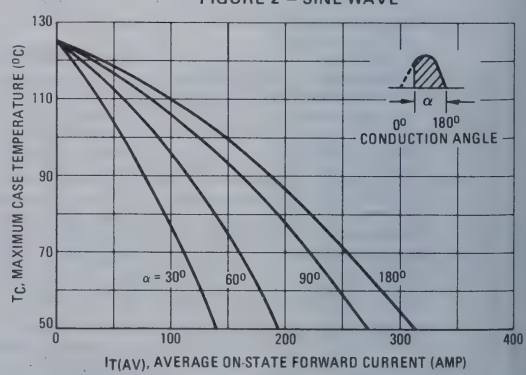


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

(f = 50 to 400 Hz)

FIGURE 3 – SQUARE WAVE

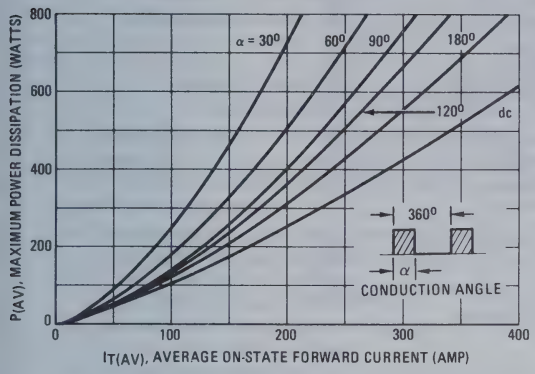


FIGURE 4 – SINE WAVE

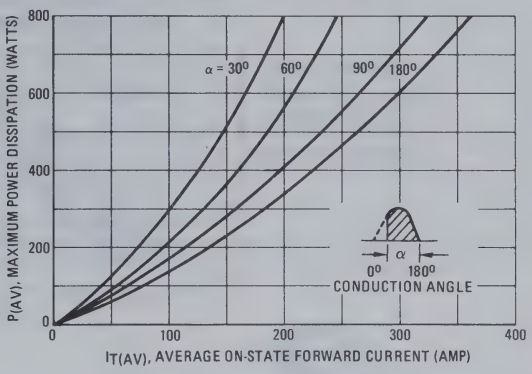


FIGURE 5 – MAXIMUM ON-STATE VOLTAGE

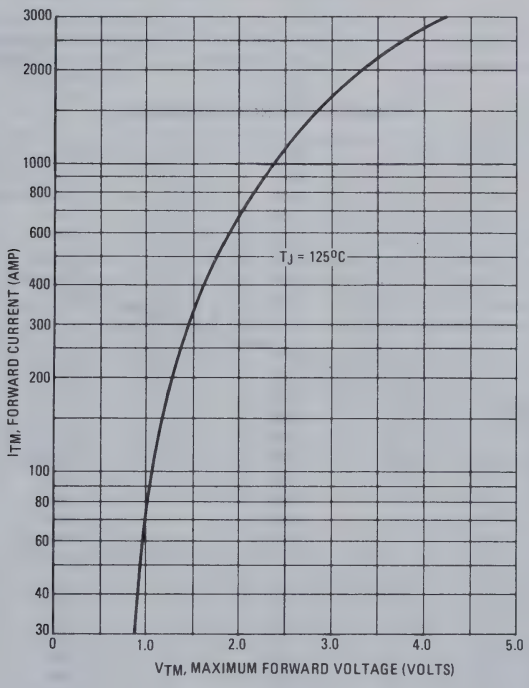


FIGURE 6 – TRIGGERING CHARACTERISTICS

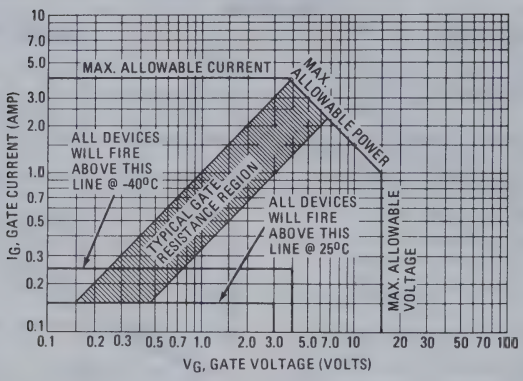
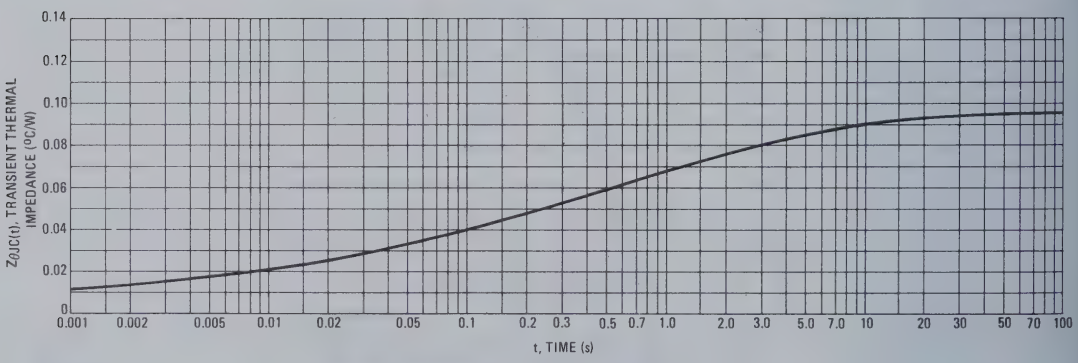


FIGURE 7 – THERMAL RESPONSE



MCR380B SERIES (SILICON)
MCR380C SERIES
MCR380D SERIES

Advance Information

BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

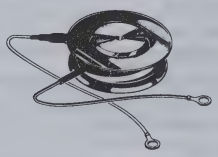
... designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses — @ 3.0 μs with 30 μs Pulse, Ip = 150 A
  MCR380B Series = 3.0 Volts
  MCR380C Series = 6.0 Volts
  MCR380D Series = 6.0 Volts
- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time — 15 to 30 μs

*With 0.05 μF and 20 ohm snubber circuit.

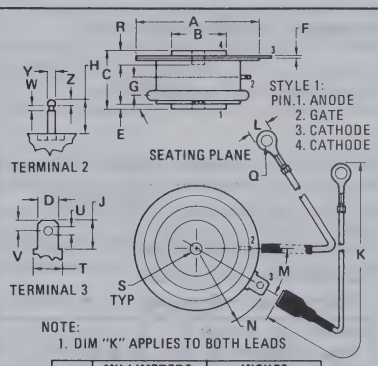
BEAM-FIRED INTEGRATED GATE THYRISTORS

380 AMPERES RMS



MAXIMUM RATINGS

Device Type		Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 15 μs Max			
MCR380B	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
Turn-Off Time = 20 μs Max			
MCR380C	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
Turn-Off Time = 30 μs Max			
MCR380D	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
	-110	1100	1200
	-120	1200	1300



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	–	0.300	–
H	3.94	–	0.155	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180° Conduction Angle)	$I_{T(AV)}$	250	Amp
Peak Surge Current (One cycle, 60 Hz, $T_J = -40$ to $+125^oC$)	I_{TSM}	3500	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+125^oC$, t = 1.5 – 8.3 ms)	I^2t	50,000	A^2s
Peak Gate Power	P_{GFM}	15	Watts
Average Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC
Mounting Force	–	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current – Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.095	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 125^oC$)		I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 125^oC$)		I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Duty Cycle ≤ 0.01%, $T_J = 25^oC$)		V_{TM}	–	–	2.65	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)		I_H	–	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 ohms, $T_J = 125^oC$)		V_{GDM}	0.15	–	–	Volts
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, $T_J = +125^oC$, di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps, I_{TM} = 250 A; dv/dt = 20 V/μs)	MCR380B MCR380C MCR380D	t_q	– – –	– – –	15 20 30	μs
Transient Turn-On Voltage (V_{DRM} = 100 V, I_{TM} = 300 A, PW = 8.0 μs, Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	MCR380B MCR380C MCR380D	V_{TO}	– – –	– – –	5.0 8.0 8.0	Volts
Critical Exponential Rate of Rise (Rated V_{DRM}, Gate open, $T_J = 125^oC$)		dv/dt	200	–	–	V/μs

MCR406-1 (SILICON)
thru
MCR406-4



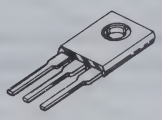
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for high volume consumer applications, such as temperature, light, and speed control, process and remote control, and warning systems where reliability of operation is important. Sensitive gate trigger permits operation as a switch directly from low level sensors.

- Annular Passivated Surface for Reliability and Uniformity
- True Power Rated – 4.0 Amp @ T_C = 97°C
- Low Level Gate Characteristics – I_{GT} = 200 μA @ T_A = 25°C
- Higher Surge Current Rating – I_{TSM} = 30 Amp
- Flat, Rugged, Thermopad†† Construction – for Low Thermal Resistance, High Heat Dissipation, and Durability

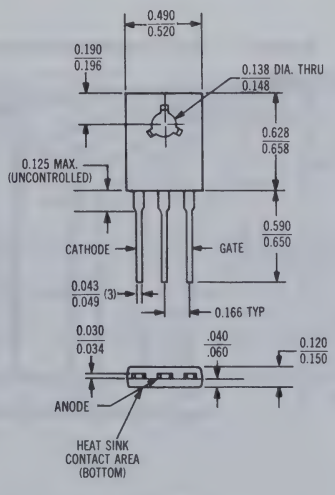
PLASTIC SILICON CONTROLLED RECTIFIERS

4.0 AMPERES RMS
30 thru 200 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR406-1 MCR406-2 MCR406-3 MCR406-4	V_{RRM}	30 60 100 200	Volts
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (1/2 cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	30	Amp
Circuit Fusing Considerations (T_J = -40 to 110°C, t = 1.0 to 8.3 ms)	I^2t	3.6	A^2s
Peak Gate Power – Forward	P_{GFM}	0.5	Watt
Average Gate Power – Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current – Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage – Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 screw) (Note 2)	–	8	in. lb.



CASE 90

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1	MCR406-1	V_{DRM}	30	–	–	Volts
	MCR406-2		60	–	–	
	MCR406-3		100	–	–	
	MCR406-4		200	–	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 110°C)		I_{DRM}	–	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 110°C)		I_{RRM}	–	–	100	μA
Forward "On" Voltage (I_{TM} = 4.0 A peak)		V_{TM}	–	–	2.2	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		I_{GT}	–	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		V_{GT}	–	–	0.8	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms, T_J = 110°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc)		I_H	–	–	3.0	mA
Turn-On Time		t_{on}	Circuit Dependent. Consult Manufacturer.			
Turn-Off Time		t_{off}				
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/μs
Thermal Resistance, Junction to Case		θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	–	50	°C/W

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

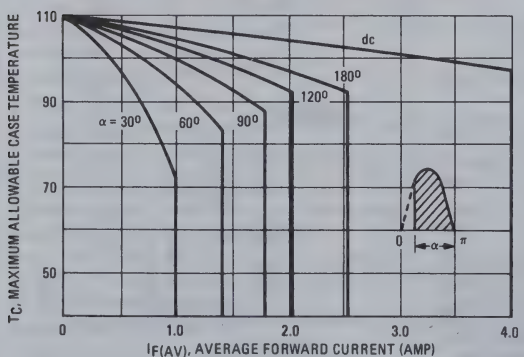


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT

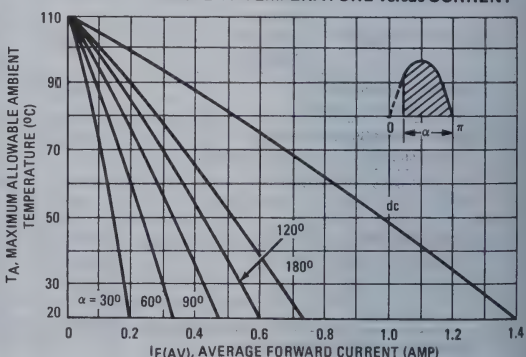


FIGURE 3 – FORWARD CONDUCTION CHARACTERISTICS

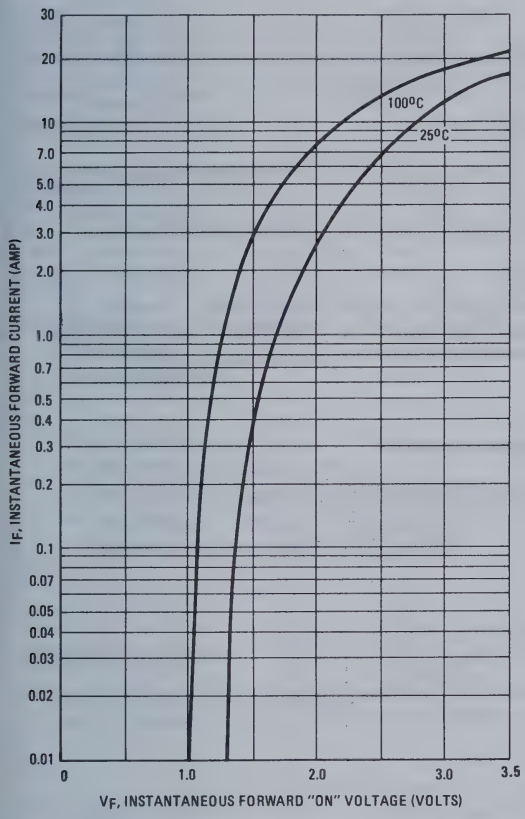


FIGURE 4 – P_D, POWER DISSIPATION

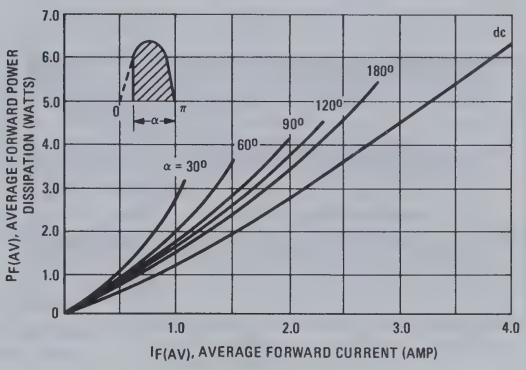


FIGURE 5 – 60 Hz SURGES

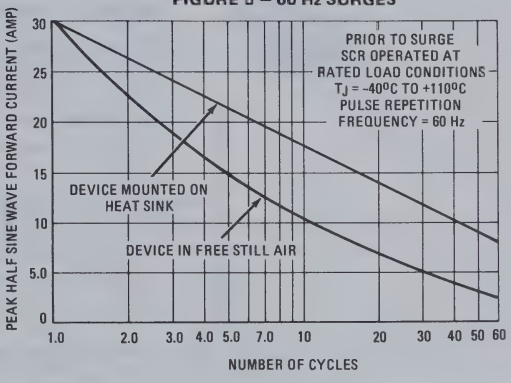


FIGURE 6 – THERMAL RESPONSE

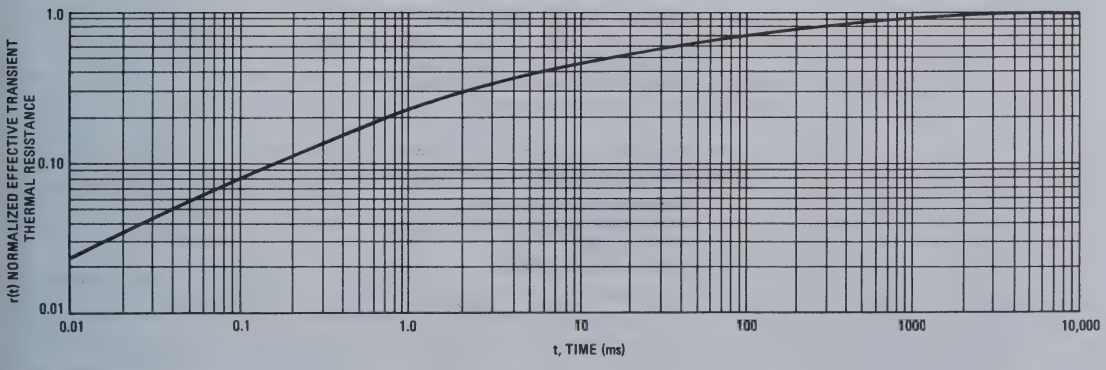


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

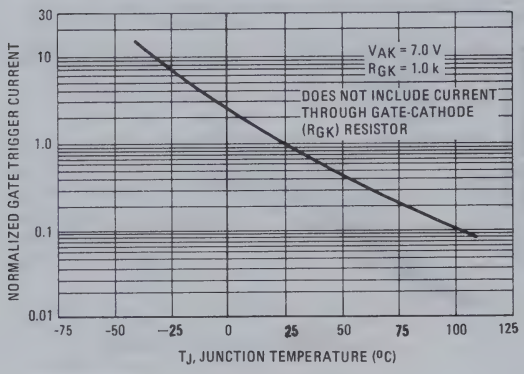


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE

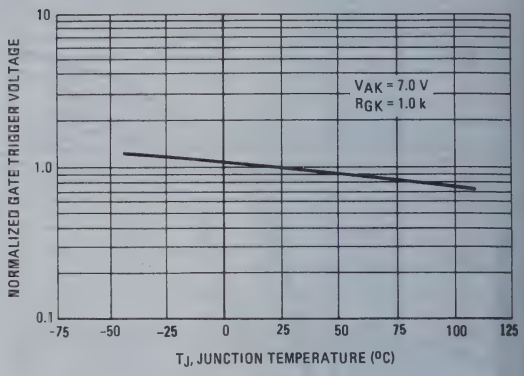
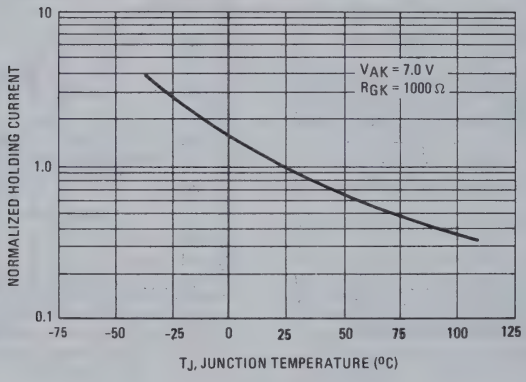


FIGURE 9 – TYPICAL HOLDING CURRENT



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240 – SCR Power Control Fundamentals
AN-290A – Mounting Procedure for, and Thermal Aspects of, Thermopad†† Plastic Power Devices
AN-295 – Suppressing RFI in Thyristor Circuits
AN-453 – Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MCR407-1 (SILICON)
thru
MCR407-4



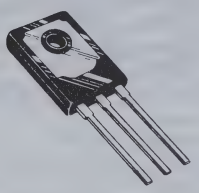
PLASTIC SILICON CONTROLLED RECTIFIERS

. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction--for Low Thermal Resistance, High Heat Dissipation and Durability

THYRISTORS

4.0 AMPERES RMS
30 thru 200 VOLTS

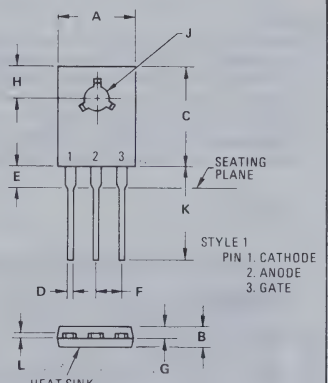


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage (Note 1) MCR407-1	V_{RRM}	30	Volts
-2		60	
-3		100	
-4		200	
RMS On-State Current (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Average On-State Current (T_C = 89°C)	$I_{T(AV)}$	2.55	Amp
Peak Non-Repetitive Surge Current (One cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	20	Amp
Circuit Fusing Considerations (T_J = -40 to +110°C) t = 1.0 to 8.3 ms)	I^2t	1.6	A^2s
Peak Gate Power	P_{GFM}	0.5	Watt
Average Gate Power	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current	I_{GFM}	0.2	Amp
Peak Gate Voltage	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 Screw) (Note 2)	—	8.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	50	°C/W



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.490	0.520	12.450	13.210
B	0.120	0.150	3.050	3.810
C	0.628	0.658	15.950	16.710
D	0.043	0.049	1.090	1.250
E	—	0.125	—	3.180
F	0.166 TP		4.220 TP	
G	0.075	0.085	1.910	2.160
H	0.177	0.197	4.500	5.000
J	0.138	0.148	3.510	3.760
K	0.590	0.650	14.990	16.510
L	0.030	0.034	0.762	0.864

NOTE:
DIM. "E" UNCONTROLLED

CASE 90-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1	MCR407-1	V_{DRM}	30	–	–	Volts
	-2		60	–	–	
	-3		100	–	–	
	-4		200	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C)		I_{DRM}	–	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)		I_{RRM}	–	–	100	μA
Peak On-State Voltage (I_{TM} = 4.0 A)		V_{TM}	–	–	2.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms)		I_{GT}	–	–	500	μA
Gate Trigger Voltage (Continuous dc)		V_{GT}				Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms)			–	–	1.0	
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)			0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc)		I_H	–	–	5.0	mA
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/μs

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

CURRENT DERATING

FIGURE 1 – MAXIMUM CASE TEMPERATURE

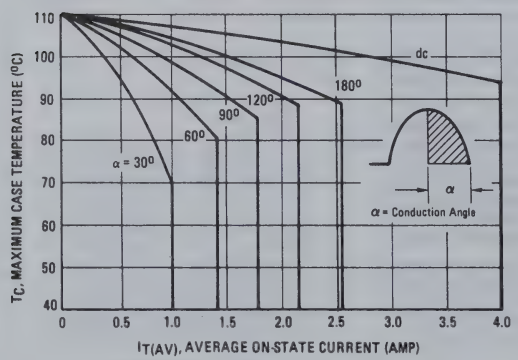
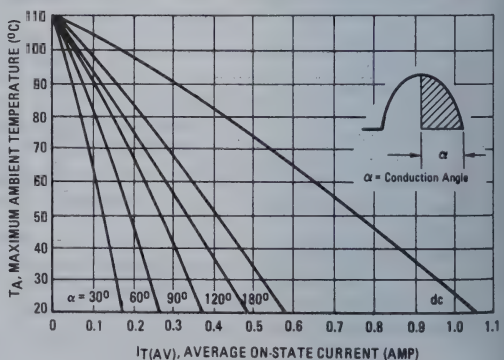


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



MCR470 SERIES (SILICON)

BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

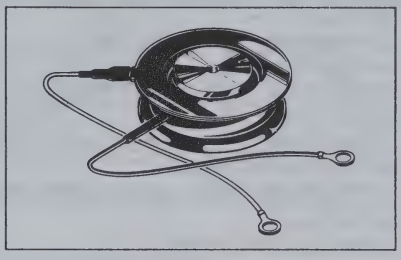
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Low Switching Losses
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 μF and 20 ohm snubber circuit.

BEAM-FIRED INTEGRATED GATE THYRISTORS

470 AMPERES RMS
100 thru 1500 VOLTS



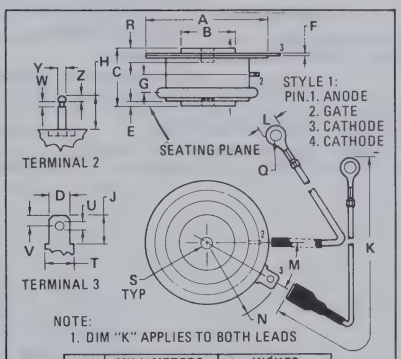
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR470 —	– 10	$V_{DRM(1)}$	100	Volts
	– 20		200	
	– 30		300	
	– 40		400	
	– 50		500	
	– 60		600	
	– 70		700	
	– 80		800	
	– 90		900	
	–100		1000	
	–110		1100	
	–120		1200	
	–130		1300	
	–140		1400	
	–150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ≤ 5.0 ms) MCR470 —	– 10	V_{RSM}	200	Volts
	– 20		300	
	– 30		400	
	– 40		500	
	– 50		600	
	– 60		720	
	– 70		840	
	– 80		960	
	– 90		1080	
	–100		1200	
	–110		1300	
	–120		1450	
	–130		1550	
	–140		1650	
	–150		1800	
Average Forward Current (180° Conduction Angle, T_C = 75°C)		$I_{T(AV)}$	300	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	5500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms)	I^2t	50,000	A^2s
	(t = 8.3 ms)		120,000	
Peak Forward Gate Power		P_{GFM}	15	Watts
Average Forward Gate Power		$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		–	1000	lbs.
Critical Rate-of-Rise of On-State Current during Turn ± On Interval (Non-Repetitive Rating)		di/dt	1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.08	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	–	0.300	–
H	3.94	–	0.155	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	–	–	1.9	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse { 10 V open circuit, 20 Ohm Source; 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Pulse { 5.0 V open circuit, 5.0 Ohm Source; 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

CURRENT DERATING

(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

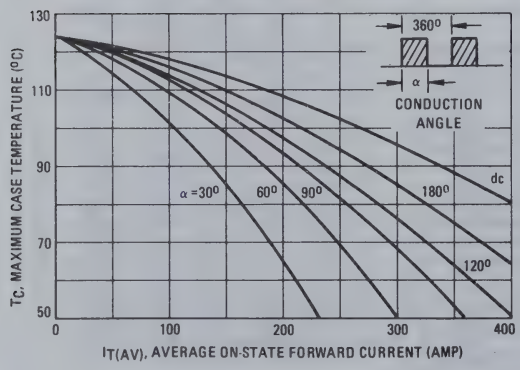


FIGURE 2 – SINE WAVE

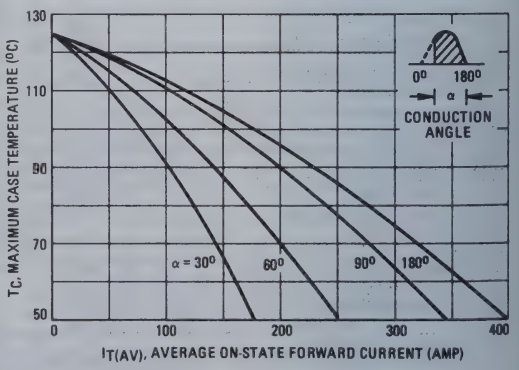


FIGURE 3 – SQUARE WAVE

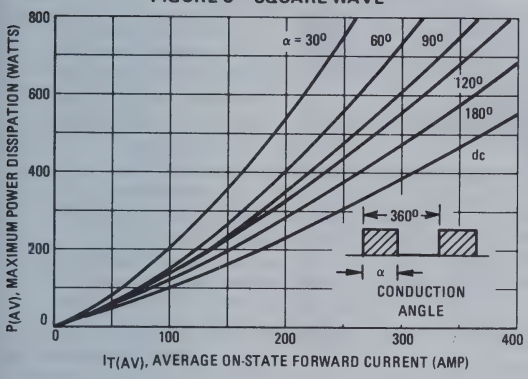


FIGURE 4 – SINE WAVE

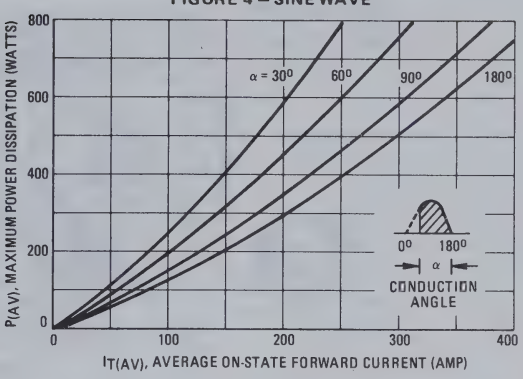


FIGURE 5 – MAXIMUM ON-STATE VOLTAGE

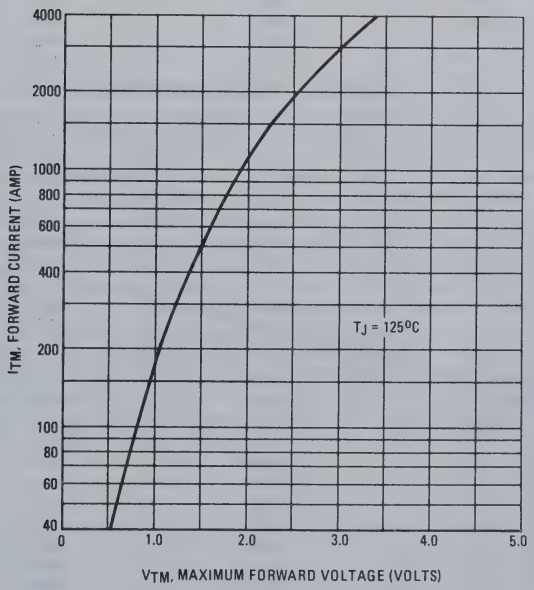


FIGURE 6 – TRIGGERING CHARACTERISTICS

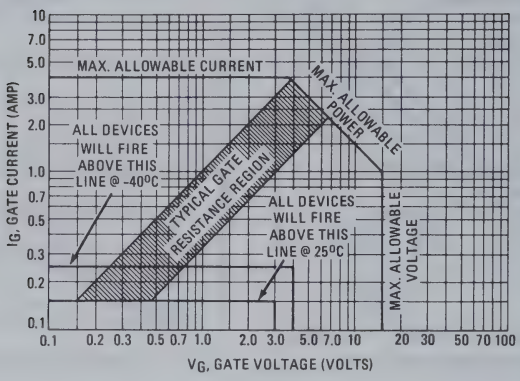
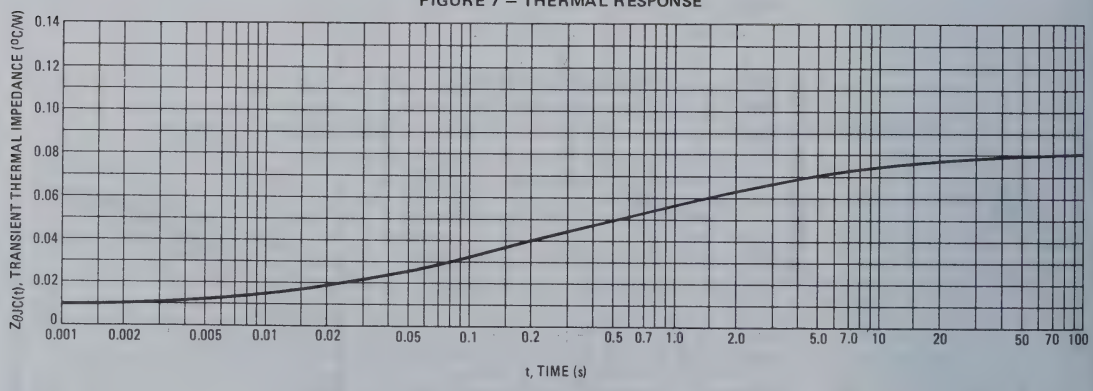


FIGURE 7 – THERMAL RESPONSE



MCR470C SERIES (SILICON)
MCR470D SERIES
MCR470E SERIES

Advance Information

BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

... designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses – @ 3.0 μs with 30 μs Pulse, Ip = 150 A
  - MCR470C Series – 3.0 Volts
  - MCR470D Series – 6.0 Volts
  - MCR740E Series – 6.0 Volts
- Critical Rate-of-Rise of On-State Current – di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate – dv/dt = 200 V/μs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time – 20 to 40 μs

*With 0.05 μF and 20 ohm snubber circuit.

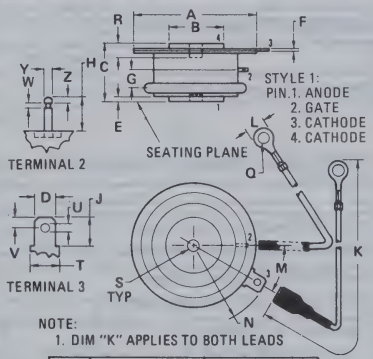
BEAM-FIRED INTEGRATED GATE THYRISTORS

470 AMPERES RMS



MAXIMUM RATINGS

Device Type		Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 20 μs Max			
MCR470C	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
Turn-Off Time = 30 μs Max			
MCR470D	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
Turn-Off Time = 40 μs Max			
MCR470E	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
	-110	1100	1200
	-120	1200	1300



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
G	7.62	–	0.300	–
H	3.94	–	0.155	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.89	1.40	0.035	0.055

CASE 220-01

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180°Conduction Angle)	$I_{T(AV)}$	300	Amp
Peak Surge Current (One cycle, 60 Hz, $T_J = -40$ to $+125^oC$)	I_{TSM}	4500	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+125^oC$, t = 1.5 - 8.3 ms)	I^2t	84,000	A^2s
Peak Forward Gate Power	P_{GFM}	15	Watts
Average Forward Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Force	—	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current — Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

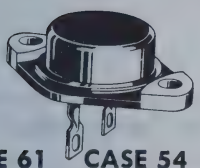
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.08	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 125^oC$)		I_{DRM}	—	—	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 125^oC$)		I_{RRM}	—	—	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Duty Cycle ≤ 0.01%, $T_J = 25^oC$)		V_{TM}	—	—	2.30	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		I_{GT}	—	—	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		V_{GT}	—	—	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)		I_H	—	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, $T_J = 125^oC$)		V_{GSM}	0.15	—	—	Volts
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, $T_J = +125^oC$, di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 250 A; dv/dt = 20 V/μs)	MCR470C MCR470D MCR470E	t_q	— — —	— — —	20 30 40	μs
Transient Turn-On Voltage (V_{DRM} = 100 V, I_{TM} = 300 A, PW = 8.0 μs Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	MCR470C MCR470D MCR470E	V_{TO}	— — —	— — —	5.0 8.0 8.0	Volts
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, $T_J = 125^oC$)		dv/dt	200	—	—	V/μs

MCR649-1 thru MCR649-7 (SILICON)



CASE 61 (TO-41)
PIN 1. GATE
2. CATHODE
CASE ANODE

CASE 54 (TO-3 Modified)
PIN 1. ANODE
2. GATE
CASE CATHODE

Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance. For units with pins (TO-3) specify devices MCR649P-1 thru MCR649P-7.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* MCR649-1	V_{ROM}*	25	Volts
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
Forward Current RMS (All Conduction Angles)	I_f	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≦ 8.3 ms)	I^2t	275	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	260	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

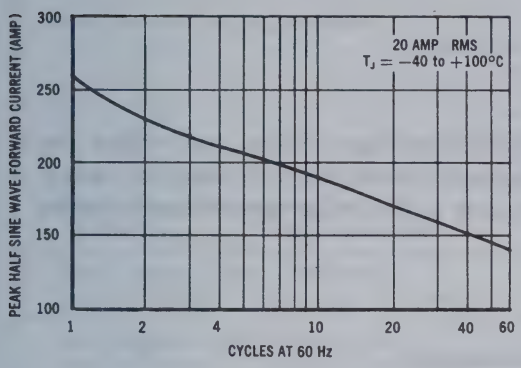
*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.

V_{ROM} ratings apply for zero or negative gate voltage.

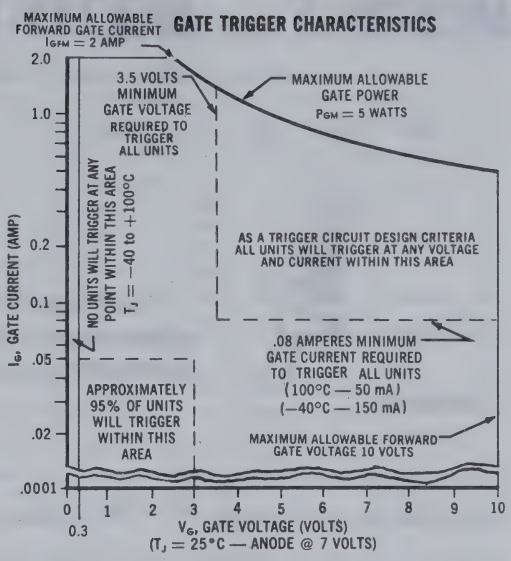
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 100°C) MCR649-1	V_{FOM}	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
-7		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 100°C)	I_{FOM}	—	—	5.0	mA
Peak Reverse Blocking Current (Rated V_{FOM} with gate open, T_J = 100°C)	I_{ROM}	—	—	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	I_{GT}	—	30	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 100°C)	V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.1	1.5	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10 A)	t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/ μs min, T_J=100°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, T_J = 100°C)	dv/dt				V/ μs
MCR649-1 thru MCR649-4		—	20	—	
MCR649-5 thru MCR649-7		—	30	—	
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	°C/W

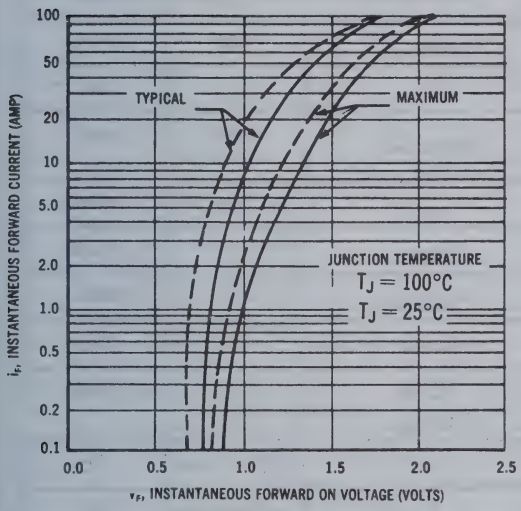
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



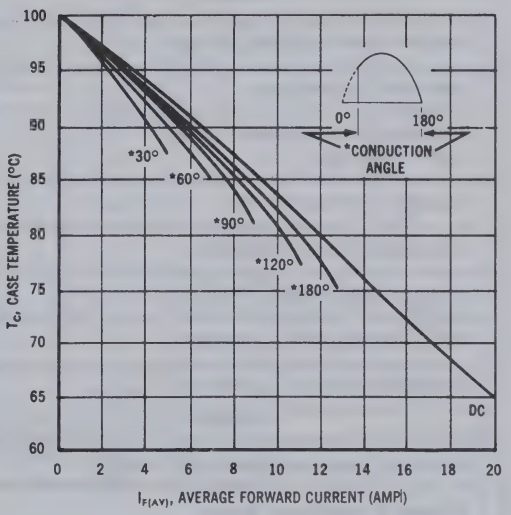
GATE TRIGGER CHARACTERISTICS



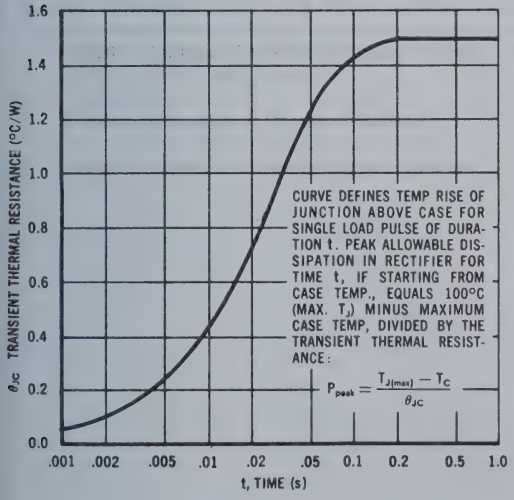
LOW CURRENT LEVEL



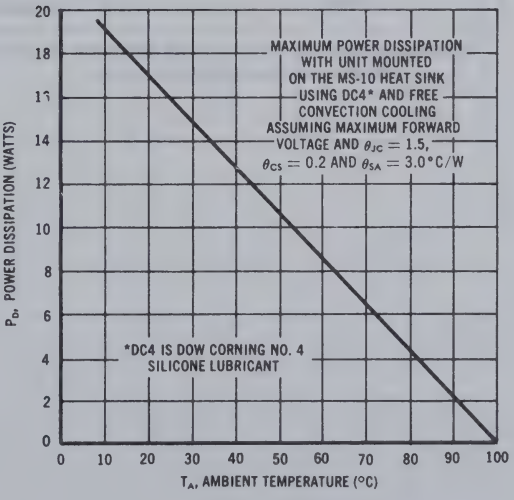
MAXIMUM ALLOWABLE CASE TEMPERATURE



MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE



MCR729-5 thru MCR729-10 (SILICON)



PIN 1. CATHODE
2. GATE
3. STUD ANODE

CASE 63

Fast-switching, high-voltage silicon controlled rectifiers especially designed and characterized for radar, proximity fuse, beacon and similar pulse applications.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*	50	Volts
Forward Current RMS	I_f	2.0	Amp
Repetitive Pulse Current (PW = 10 μs)	$I_{FM(pulse)}$	100	Amp
Average Forward Power	$P_{F(AV)}$	5.0	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to+ 105	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher V_{ROM} rated units available on request.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 105°C) MCR729-5	V_{FOM}*	300	—	—	Volts
-6		400	—	—	
-7		500	—	—	
-8		600	—	—	
-9		700	—	—	
-10		800	—	—	
Peak Forward Blocking Current (Rated V_{FOM}, T_J = 105°C, gate open)	I_{FOM}	—	0.2	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	I_{GT}	—	10	50	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, gate open)	I_{HO}	5.0	15	—	mA
Forward On Voltage (I_f = 2 Adc)	V_F	—	1.1	1.5	Volts
Dynamic Forward On Voltage (0.5 μs after 50% pt, I_G = 200 mA, I_{pulse} = 30 Amps)	$V_{F(on)}$	—	15	25	Volts
Turn-On Time (t_d + t_r) (I_G = 200 mA)	t_{on}				ns
(I_{pulse} = 30 Amps peak)	—	—	200	—	
(I_{pulse} = 100 Amps peak)		—	400	—	
Turn-On Time Variation (T_J = +25°C to +105°C and -65°C to +25°C)	Δt_{on}	—	±50	—	ns
Pulse Turn-Off Time	$t_{off(pulse)}$	—	15	—	μs
Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5 A; Rep. Rate = 100 pps; Duty cycle = 0.05%; Forward Voltage = rated V_{FOM}; T_C = 85°C; dv/dt = 250 V/μs; Reverse anode voltage applied during turn-off interval = rated V_{FOM}; Reverse gate bias during turn-off interval = -6 V; Gate Trigger Pulse: 200 mA, 1 μs wide, 2 ns rise time. Turn-off time measured from 90% pt. of forward, current decay to 10% pt. of reapplied forward voltage.					
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

*Other voltage units available upon request.

MCR846 series (SILICON)



PIN 1. CATHODE
2. GATE
3. STUD ANODE

CASE 63

Silicon controlled rectifiers for low-power switching and control applications requiring blocking to 200 volts and load currents to 2 amp.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

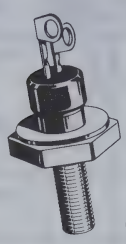
Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR846-1 -2 -3 -4	$V_{ROM(rep)}$	 25 50 100 200	Volts
Forward Current RMS (all conduction angles)	I_f	2.0	Amp
Circuit Fusing Considerations (T_J = -65 to +105°C; t ≦ 8.3 ms)	I^2t	35	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +105°C)	$I_{FM(surge)}$	30	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	15	in - lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 105°C) MCR846-1	V_{FOM}	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 105°C)	I_{FOM}	—	—	2.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 105°C)	I_{ROM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	15	—	mA
Forward On Voltage (I_F = 2 Adc)	V_F	—	1.3	1.6	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 2 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 2 A, I_R = 10 A, dv/dt = 50 V/μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	6.0	—	μs
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

MCR1336-5 (SILICON)
thru
MCR1336-10

PIN 1. CATHODE
2. GATE
3. STUD ANODE



CASE 63

Fast switching, high-voltage thyristors especially designed for pulse modulator applications in radar and other similar equipment.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* (T_J = 105°C)	$V_{ROM(rep)}$*	50	Volts
Repetitive Peak Forward Current (PW = 3.0 μs, Duty Cycle = 0.6%, T_C = 85° C max)	$I_{FM(rep)}$	300	Amp
Current Application Rate**	di/dt**	1000	A/μs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward Reverse***	V_{GFM} V_{GRM}***	7.0 7.0	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	-	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous dc voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

**Minimum Gate Trigger Pulse: i_G = 500 mA, PW = 1.0 μs, t_r = 20 ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage* (T_C = 105°C)	V_{FOM}*				Volts
MCR1336 -5		300	-	-	
MCR1336 -6		400	-	-	
MCR1336 -7		500	-	-	
MCR1336 -8		600	-	-	
MCR1336 -9		700	-	-	
MCR1336 -10		800	-	-	
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM}, T_C = 105°C, gate open)	I_{FOM}	-	-	2.0	mA
	I_{ROM}	-	-	2.0	
Gate Trigger Current (Continuous dc)	I_{GT}				mA
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		-	-	40	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)		-	-	100	
Gate Trigger Voltage (Continuous dc)	V_{GT}				Volts
(Anode Voltage = rated V_{FOM}, R_L = 100 ohms, T_C = 105°C)		0.2	-	-	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		-	-	1.25	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)		-	-	2.0	
Holding Current	I_{HO}				mA
(Anode Voltage = 7.0 Vdc, gate open, T_C = 105°C)		1.0	-	-	
(Anode Voltage = 7.0 Vdc, gate open, T_C = 25°C)		-	-	50	
Forward "On" Voltage (I_f = 1.0 Adc, PW = 1.0 ms max, Duty cycle ≤ 1.0%)	V_F	-	-	2.0	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform) Forward Current: 100 A pulse (PFN discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns	$V_{F(on)}$	-	45	-	Volts
Turn-On Time					ns
Delay Time	t_d	-	75	-	
Rise Time	t_r	-	75	-	
Forward Current: 100 A Pulse (Capacitor discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns					
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 100 A pulse; Reverse Current = 5.0 A, T_C = 85°C, dv/dt = 250 V/μs to Rated V_{FOM}; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.	$t_{off(pulse)}$	-	7.0	-	μs
Forward Voltage Application Rate (Linear Rise of Voltage) (T_C = 105°C, gate shorted)	dv/dt	250	-	-	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	-	-	2.5	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

MCR1718-5 (SILICON)
thru
MCR1718-8

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . fast switching, high-voltage thyristors especially designed for pulse modulator applications.

- High-Voltage Capability from 300 to 600 Volts
- Repetitive Pulse Current to 1000 Amp
- Pulse Repetition as High as 4000 pps
- Current Application Rate as High as 1000 A/μs

THYRISTORS
PNPN

25 AMPERES RMS
300 thru 600 VOLTS

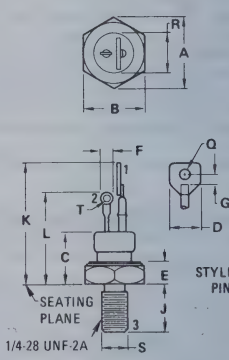


Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage(1)	V_{RRM}		Volts
MCR1718-5		300	
-6		400	
-7		500	
-8		600	
Non-Repetitive Peak Reverse Voltage (Transient) (Non-Recurrent 5 ms (max)	V_{RSM}		Volts
MCR1718-5		400	
-6		500	
-7		600	
-8		700	
Forward Current RMS	$I_{T(RMS)}$	25	Amp
Peak Forward Surge Current (1-10 μs Pulse Width)	I_{TSM}	1000	Amp
Current Application Rate (up to 1000 Adc peak)	di/dt	1000	A/μs
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 1.0 ms	I^2t	250	A^2s
Dynamic Average Power (T_C = 65°C)	$P_{F(AV)}$	30	Watts
Peak Gate Power - Forward	P_{GM}	20	Watts
Average Gate Power - Forward	$P_{G(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GM}	5.0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	–	30	in.-lb

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W



STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	16.51	–	0.650
B	13.82	14.27	0.544	0.562
C	8.40	12.80	0.330	0.505
D	5.34	7.62	0.210	0.300
E	2.88	5.08	0.113	0.200
F	2.93	3.55	0.115	0.140
G	3.05	–	0.120	–
H	–	2.28	–	0.090
J	10.72	11.50	0.422	0.453
K	23.11	30.30	0.910	1.193
P	5.59	6.32	0.220	0.249
Q	3.18	4.19	0.125	0.165
R	–	13.82	–	0.544
S	5.652	5.760	0.2225	0.2268
T	3.18	–	0.125	–
U	1.53	1.90	0.060	0.075

All JEDEC dimensions and notes apply

CASE 64-02
TO-48

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (1)		V_{DRM}				Volts
(T_J = 125°C)	MCR1718-5		300	–	–	
	-6		400	–	–	
	-7		500	–	–	
	-8		600	–	–	
Peak Forward Blocking Current		I_{DRM}				mA
(Rated V_{DRM} with gate open, T_J = 125°C)			–	–	8.0	
Peak Reverse Blocking Current		I_{RRM}				mA
(Rated V_{RRM} with gate open, T_J = 125°C)			–	–	8.0	
Forward "On" Voltage		V_{TM}				Volts
(I_F = 25 Adc)			–	1.1	1.3	
(I_{GT} = 500 mA, I_{pulse} = 500 Amps)						
(1.0 μs after start (10% pt.) of I_{pulse})			–	30	–	
(5.0 μs after start (10% pt.) of I_{pulse})			–	5.0	–	
Gate Trigger Current (Continuous dc)		I_{GT}				mA
(Anode Voltage = 7.0 Vdc, R_L = 50 Ohms)			–	10	50	
Gate Trigger Voltage (Continuous dc)		V_{GT}				Volts
(Anode Voltage = 7.0 Vdc, R_L = 50 Ohms)			–	0.8	1.5	
(Anode Voltage = Rated V_{DRM}, R_L = 500 Ohms, T_J = 125°C)		V_{GD}	0.25	–	–	
Holding Current		I_H				mA
(Anode Voltage = 7.0 Vdc, Gate Open)			5.0	15	–	
(Anode Voltage = 7.0 Vdc, Gate Open, T_J = 125°C)			–	6.0	–	
Circuit Commutated Turn-Off Time		t_q				μs
(I_F = 500 A, I_R = 10 A, dv/dt = 20 V/μs)			–	20	–	
(Conductive Charging Circuit – Circuit dependent)						
Critical Exponential Rate of Rise		dv/dt				V/μs
(Gate Open, T_J = 125°C)			–	100	–	

(1) V_{DRM} for all types can be supplied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1906-1 thru MCR1906-4 (SILICON)

SILICON CONTROLLED RECTIFIERS

. . . designed for applications in control systems and sensing circuits where low-level gating and holding characteristics are necessary.

- Low-Level Gate Characteristics — I_{GT} = 1.0 mA (Max) @ T_C = 25°C
- Low Holding Current — I_H = 5.0 mA (Max) @ T_C = 25°C
- Anode Common to Case
- Glass-to-Metal Bond for Maximum Hermetic Seal

THYRISTORS
PNPN

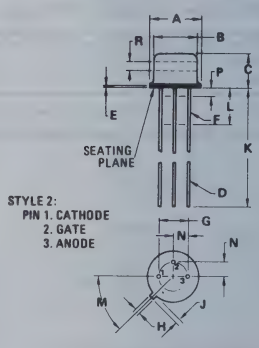
1.6 AMPERES RMS
25 thru 200 VOLTS

DS 6520



MAXIMUM RATINGS (T_J = 100°C unless otherwise noted.)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1)	V_{RRM}		Volts
MCR1906-1		25	
MCR1906-2		50	
MCR1906-3		100	
MCR1906-4		200	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = −40 to +100°C) No Repetition Until Thermal Equilibrium is Restored	I_{TSM}	15	Amp
Peak Gate Power-Forward	P_{GM}	0.1	Watt
Average Gate Power-Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current-Forward	I_{GM}	0.1	Amp
Peak Gate Voltage	V_{GM}	6.0	Volt
Operating Junction Temperature Range	T_J	−65 to +100	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Lead Solder Temperature (>1/16" From Case, 10 s max.)	—	+230	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.
CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms.)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1)	V_{DRM}			Volt
MCR1906-1		25	–	
MCR1906-2		50	–	
MCR1906-3		100	–	
MCR1906-4		200	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C)	I_{DRM}	–	500	μA
Peak Reverse Blocking Current (3) (Rated V_{RRM}, T_J = 100°C)	I_{RRM}	–	500	μA
Forward "On" Voltage (Pulsed, 1.0 ms max, Duty Cycle ≤ 1.0%) (I_F = 1.0 Adc peak)	V_{TM}	–	1.75	Volt
Gate Trigger Current (2) (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 ohms)	I_{GT}	–	1.0	mAdc
Gate Trigger Voltage (Continuous dc)				Volt
(Anode Voltage = 7.0 V, R_L = 100 ohms)	V_{GT}	–	1.0	
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 100°C)	V_{GD}	0.1	–	
Holding Current (Anode Voltage = 7.0 V)	I_H	–	5.0	mA
Turn-On Time	t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_{off}			

(1) V_{RRM} and V_{DRM} can be applied for all types on a continuous dc basis without incurring damage. Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) R_{GK} current is not included in measurement.

(3) Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

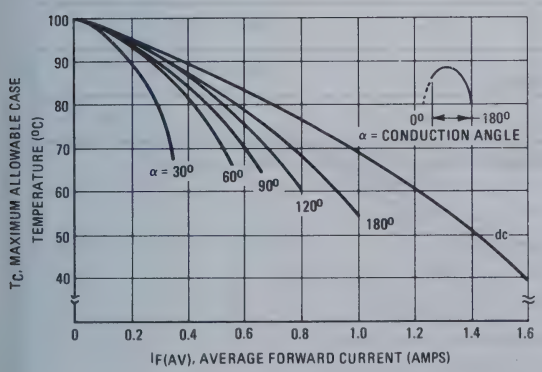
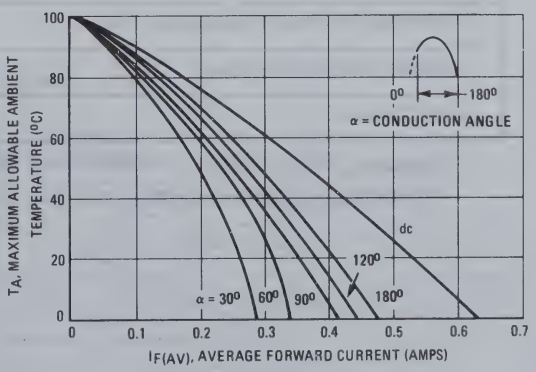


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT



MCR1907-1 thru MCR1907-6 (SILICON)



PIN 1. CATHODE
2. GATE
3. STUD ANODE

CASE 64
(TO-48)

Fast turn-on, fast turn-off silicon controlled rectifiers for high-frequency applications requiring blocking to 400 volts and load currents to 25 amp.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
MCR1907-1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
Peak Reverse Blocking Voltage (Non-Recurrent 5 ms (max.)	$V_{ROM(non-rep)}$		Volts
MCR1907-1		35	
-2		75	
-3		150	
-4		300	
-5		400	
-6		500	
Forward Current RMS (All Conduction Angles)	I_f	25	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 8.3 ms)	I^2t	75	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	150	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current — Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in. lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1907-1 thru MCR1907-6 (continued)

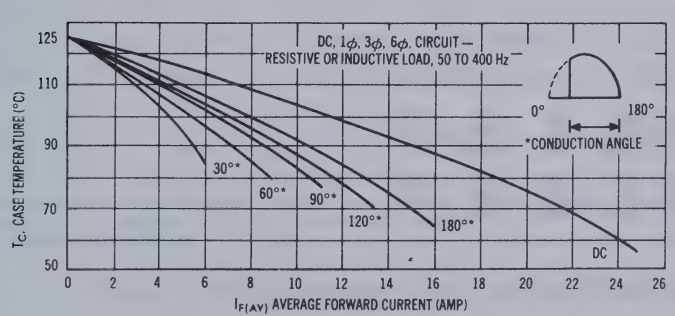
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1907-1	V_{FOM}*	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	4.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	4.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω)	I_{GT}	—	15	30	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	—	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	12	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.4	1.7	Volts
Turn-On Time (I_G = 200 mA, I_F = 10 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 30 V/μs min.) (V_{FXM} = rated voltage) T_J = 125°C (V_{RXM} = rated voltage)	t_{off}	—	—	12	μs
Forward Voltage Application Rate (T_J = 125°C, gate open)	dv/dt	30	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.7	°C/W

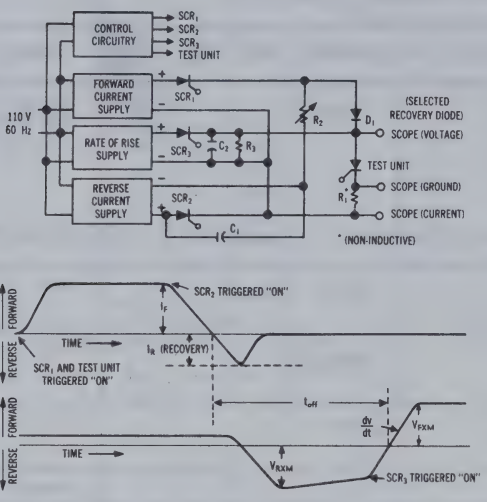
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage. These devices should never be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

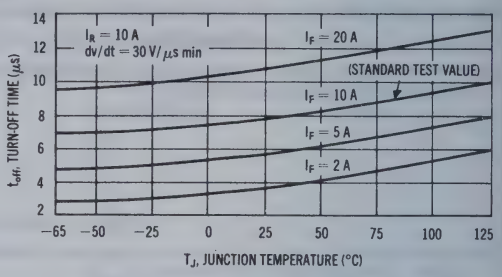
CURRENT DERATING



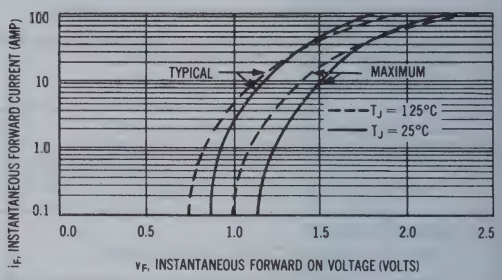
TURN-OFF TIME TEST CIRCUIT †



TYPICAL TURN-OFF TIME versus PEAK FORWARD CURRENT AND JUNCTION TEMPERATURE



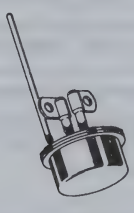
FORWARD CONDUCTING CHARACTERISTICS



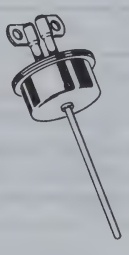
Forward conduction current is passed through the device (SCR_1 and test device triggered on). The anode is then driven negative (SCR_2 triggered on), causing reverse current to flow. The anode-to-cathode potential goes negative with a decrease in reverse current. Forward voltage is then applied to the anode of the device (SCR_3 triggered on). The device has fully recovered when it regains its ability to block the reapplied forward voltage.

† Consult manufacturer for further circuit information.

MCR2604-1 thru MCR2604-8
MCR2605-1 thru MCR2605-8



CASE 87
MCR2604-1
thru
MCR2604-8



CASE 88
MCR2605-1
thru
MCR2605-8

These series of silicon controlled rectifiers are electrically identical to the 2N4151 thru 2N4198 series, but are available in the cases illustrated.

MCR2818-1, -3, -5, -7
MCR2918-1, -3, -5, -7

For Specifications, See Thyristor Selector Guide

MCR2315 SERIES (SILICON)
MCR2614L SERIES

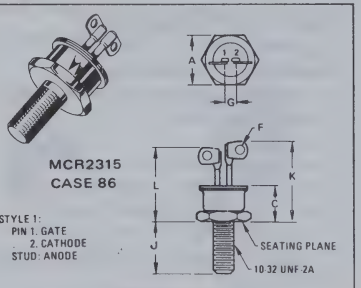
SILICON CONTROLLED RECTIFIERS

. . . designed for applications requiring blocking voltages through 400 volts and rms currents through 8.0 amperes. These devices are available in a choice of space-saving, economical packages for mounting versatility.

- Low Forward Voltage Drop — Typically 1.0 Volt at 5.0 A at 25°C
- Fast, Stable Switching Times — Typically 1.0 μs Turn-On, 12 μs Turn-Off at 25°C
- All-Diffused Junctions for Greater Parameter Uniformity
- Fatigue-Free Solder Construction
- Glass-to-Metal Hermetic Seal

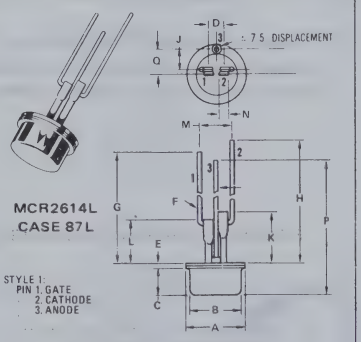
SILICON CONTROLLED RECTIFIERS

8.0 AMPERES RMS
25 thru 400 VOLTS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.10	–	0.437
C		7.87	–	0.310
F	1.78 TYP		0.070 TYP	
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	–	16.76	–	0.660
L	–	15.49	–	0.610

NOTE:
1. DIM "G" MEASURED AT CAN.



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	–	0.430	–	10.920
B	–	0.350	–	8.890
C	–	0.185	–	4.700
D	0.090	0.110	2.290	2.790
E	0.030	0.050	0.762	1.270
F	0.030	0.034	0.762	0.864
G	1.240 TYP		31.500 TYP	
H	1.320	–	33.530	–
J	0.135	0.145	3.430	3.680
K	–	0.320	–	8.130
L	–	0.270	–	6.860
M	0.190	0.210	4.830	5.330
N	0.065	0.075	1.650	1.910
P	1.200	–	30.480	–
Q	0.180	0.200	4.570	5.080

NOTES
1. DIM "D" MEASURED AT CAN.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
MCR2315 −1		25	
MCR2315 −2		50	
MCR2315 −3		100	
MCR2614L −4		200	
MCR2614L −5		300	
MCR2614L −6		400	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	8.0	Amp
Peak Forward Surge Current (One cycle, 60 Hz, T_J = −40 to +100°C) Forward Polarity	I_{TSM}	80	Amp
Circuit Fusing Considerations (T_J = −40 to +100°C; t ⩽ 8.3 ms) Forward Polarity	I^2t	40	A^2s
Peak Gate Power — Forward	P_{GM}	5.0	Watts
Average Gate Power — Forward	$P_{GM(AV)}$	0.5	Watt
Peak Gate Current — Forward	I_{GM}	2.0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
Operating Junction Temperature Range	T_J	−40 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque (MCR2315 series)		15	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MCR2315		1.5	2.7	
MCR2614L		1.8	3.0	
Thermal Resistance, Case to Ambient	$R_{\theta CA}$			°C/W
MCR2614L		50(2)	–	

(2) Applies for the worst-case conditions of: (a) highest $R_{\theta CA}$ package configuration, (b) leads terminated at end points, (c) temperature measured at hottest spot on device (center of case bottom), and (d) still air mounting.

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Apply to all case types unless otherwise noted

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (1) (T_J = 100°C) MCR2315 / MCR2614L -1	V_{DRM}	25	–	–	Volts
-2		50	–	–	
-3		100	–	–	
-4		200	–	–	
-5		300	–	–	
-6		400	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C, gate open)	I_{DRM}	–	–	3.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 100°C, gate open)	I_{RRM}	–	–	3.0	mA
Forward On Voltage (I_F = 5.0 Adc)	V_{TM}	–	1.0	1.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100Ω)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)	V_{GT}	–	0.6	1.5	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc, gate open)	I_H	–	10	50	mA
Turn-On Time (I_F = 5.0 Adc, I_{GT} = 20 mAdc)	t_{on}	–	1.0	–	μs
Circuit Commutated Turn-Off Time (I_F = 5.0 Adc, I_R = 5.0 Adc)	t_q	–	15	–	μs
(I_F = 5.0 Adc, I_R = 5.0 Adc, T_J = 100°C)		–	30	–	
Critical Exponential Rate of Rise (T_J = 100°C)	dv/dt	–	50	–	V/μs

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

Devices should not be tested with a constant current source for forward or reverse blocking capability in a manner that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING - HALF WAVE

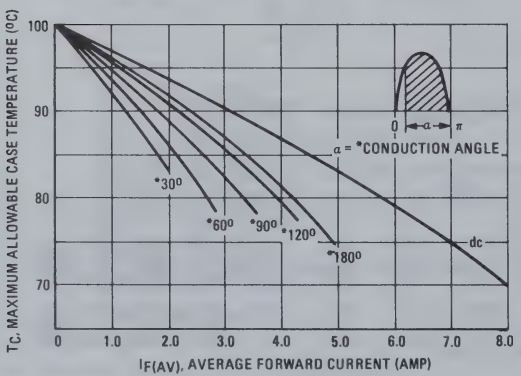
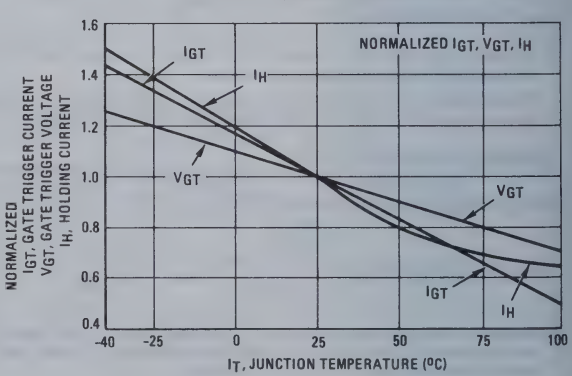


FIGURE 2 – TYPICAL PARAMETER VARIATIONS versus TEMPERATURE



MCR3818-1 thru MCR3818-8 (SILICON)
MCR3918-1 thru MCR3918-8

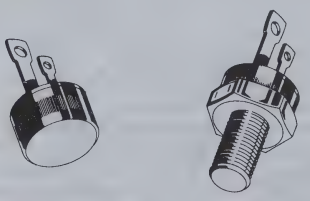
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 240 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ $T_C = 25^oC$
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

20 AMPERES RMS
25 thru 600 VOLTS

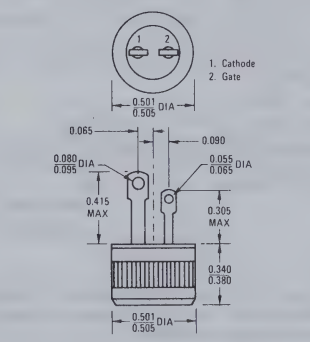


MCR3818 Series MCR3918 Series

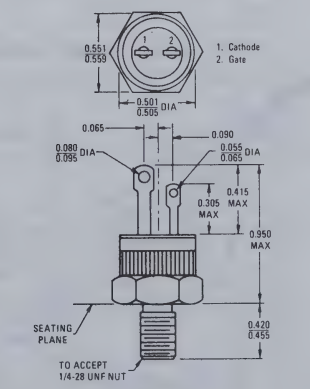
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
MCR3818	-1		25	
	-2		50	
	-3		100	
	-4		200	
MCR3918	-5		300	
	-6		400	
	-7		500	
	-8		600	
Non-repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)		V_{RSM}		Volts
MCR3818	-1		35	
	-2		75	
	-3		150	
	-4		300	
MCR3918	-5		400	
	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	20	Amp
Peak Surge Current (one cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	240	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	235	A^2s
Peak Gate Power		P_{GM}	5.0	Watt
Average Gate Power		$P_{G(AV)}$	0.5	Watt
Peak Forward Gate Current		I_{GM}	2.0	Amp
Peak Gate Voltage				Volts
Forward		V_{GFM}	10	
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3918 Series)		—	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)	V_{DRM}(1)				Volts
MCR3818 -1		25	–	–	
MCR3818 -2		50	–	–	
MCR3818 -3		100	–	–	
MCR3818 -4		200	–	–	
MCR3918 -5		300	–	–	
MCR3918 -6		400	–	–	
MCR3918 -7		500	–	–	
MCR3918 -8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)	I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)	I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 20 A Peak)	V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)	I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 20 Adc, I_{GT} = 40 mAdc)	t_{on}	–	1.0	–	μs
Turn-Off Time	t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)		–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)		–	25	–	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–			°C/W
MCR3818		–	–	1.5	
MCR3918		–	–	1.6	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

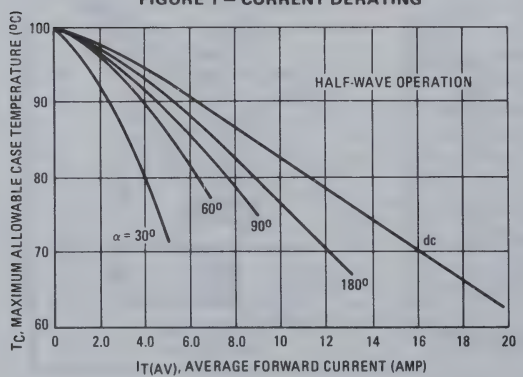
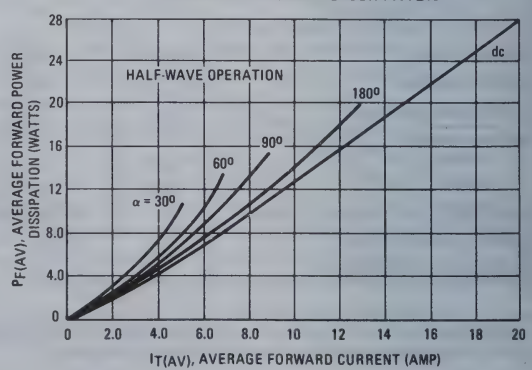


FIGURE 2 – POWER DISSIPATION



MCR3835-1 thru MCR3835-8 (SILICON)
MCR3935-1 thru MCR3935-8

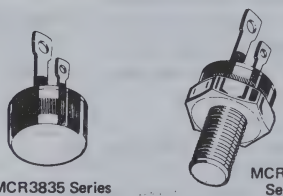
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current – I_{TSM} = 325 Amp
- Low Forward "On" Voltage – 1.2 V (Typ) @ I_{TM} = 35 Amp
- Practical Level Triggering and Holding Characteristics – 10 mA (Typ) @ $T_C = 25^oC$
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

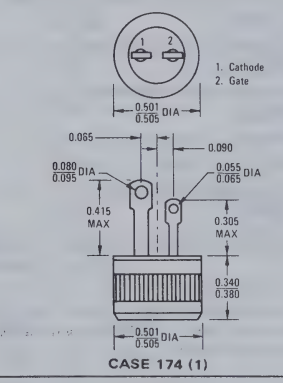
35 AMPERES RMS
25 thru 600 VOLTS



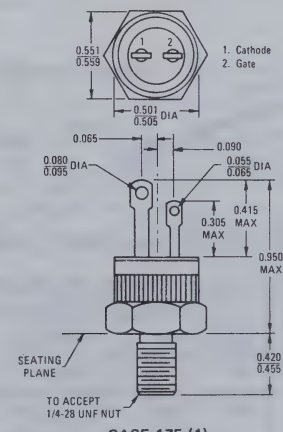
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
MCR3835	-1		25	
	-2		50	
	-3		100	
	-4		200	
MCR3935	-5		300	
	-6		400	
	-7		500	
	-8		600	
Non-Repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)		V_{RSM}		Volts
MCR3835	-1		35	
	-2		75	
	-3		150	
	-4		300	
MCR3935	-5		400	
	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	35	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	325	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	435	A^2s
Peak Gate Power		P_{GFM}	5.0	Watts
Average Gate Power		$P_{GF(AV)}$	0.5	Watt
Peak Forward Gate Current		I_{GFM}	2.0	Amp
Peak Gate Voltage – Forward Reverse		V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3935 Series)		–	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)		V_{DRM}(1)				Volts
	-1		25	–	–	
	-2		50	–	–	
	-3		100	–	–	
MCR3835	-4		200	–	–	
	-5		300	–	–	
MCR3935	-6		400	–	–	
	-7		500	–	–	
	-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)		I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)		I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 35 A Peak)		V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DM}, R_L = 100 Ω, T_J = 100°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)		I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 35 Adc, I_{GT} = 40 mAdc)		t_{on}	–	1.0	–	μs
Turn-Off Time		t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)			–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)			–	25	–	
Forward Voltage Application Rate (T_J = 100°C)		dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	MCR3835	θ_{JC}	–	–	1.2	°C/W
	MCR3935		–	–	1.3	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

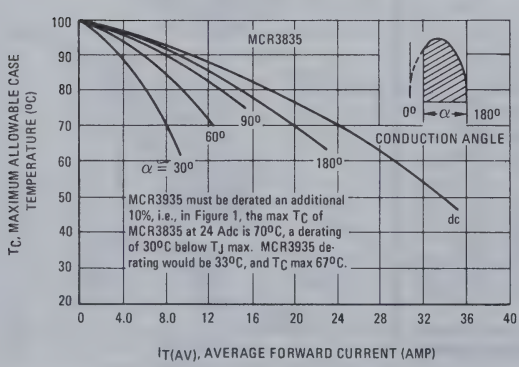
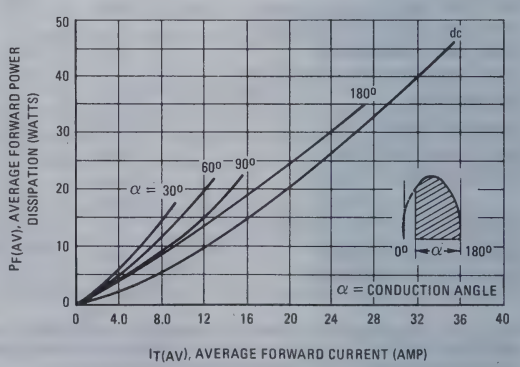


FIGURE 2 – TYPICAL POWER DISSIPATION

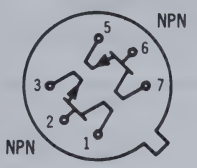


MD708, F (SILICON)
MD708A, F
MD708B, F

Dual NPN silicon annular transistors designed for high-speed, logic switching and space saving considerations. Matched pairs are available for differential amplifier applications.

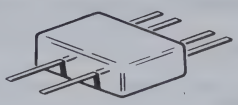


CASE
654-01

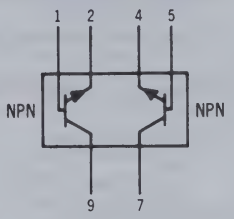


PINS 4 AND 8 OMITTED

MD708
MD708A
MD708B



Case 610-02



MD708F
MD708AF
MD708BF

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

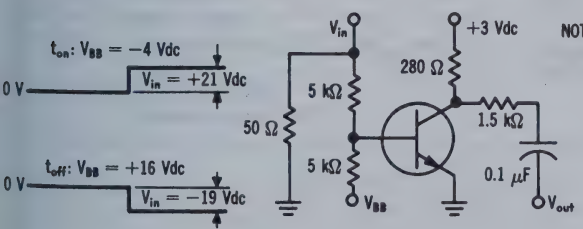
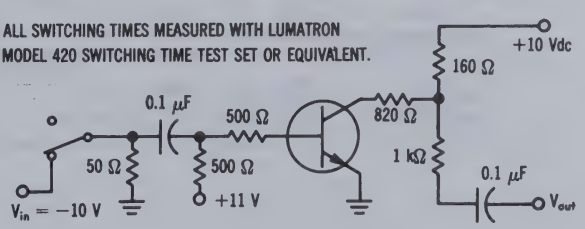


FIGURE 2 — CHARGE-STORAGE TIME CONSTANT TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage [1] (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.015	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)		—	50	
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	—	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	200	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		35	—	
(I_C = 150 mAdc, V_{CE} = 5.0 Vdc)		30	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.35	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.95	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	1.1	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	7.0	pF
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	25	ns
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{on}	—	35	ns
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{off}	—	75	ns
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 10 mAdc, V_{CE} = 1 Vdc) MD708A, MD708AF	h_{FE1}/h_{FE2}**	0.9	1.0	—
MD708B, MD708BF		0.8	1.0	
Base Voltage Differential (I_C = 10 mAdc, V_{CE} = 1 Vdc) MD708A, MD708AF	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5.0	mVdc
MD708B, MD708BF		—	10	
Base Voltage Differential Gradient (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55 to +125°C) MD708A, MD708AF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
MD708B, MD708BF		—	20	

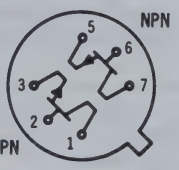
[1] Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%
**The lowest h_{FE} reading is taken as h_{FE1} for this test.

MD918, F (SILICON)
MD918A, F
MD918B, F

Dual NPN silicon annular transistors designed for ultra-high frequency oscillator and amplifier applications and for differential amplifier applications requiring a matched pair of transistors with a high degree of parameter uniformity under varying environmental conditions.



CASE 654-04

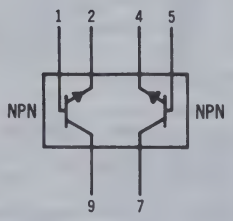


PINS 4 AND 8 OMITTED

MD918
MD918A
MD918B



CASE 610-02



MD918F
MD918AF
MD918BF

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)	BV_{CEO}	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1 μAdc, I_E = 0)	BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 0, I_E = 0, f = 140 kHz)	C_{ob}	— —	1.7 3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	2.0	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 60 MHz, R_S = 400 ohms)	NF	—	6.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio* (I_C = 1 mAdc, V_{CE} = 5 Vdc) MD918A, MD918AF MD918B, MD918BF	h_{FE1}/h_{FE2}*	0.9 0.8	1.0 1.0	—
Base Voltage Differential (I_C = 1 mAdc, V_{CE} = 5 Vdc) MD918A, MD918AF MD918B, MD918BF	$\lvert V_{BE1} - V_{BE2} \rvert$	— —	5.0 10	mVdc
Base Voltage Differential Change (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C) MD918A, MD918AF MD918B, MD918BF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	10 20	μV/°C

*The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD982 (SILICON)
MD982F
MQ982

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified —
  100 μAdc to 150 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 320 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

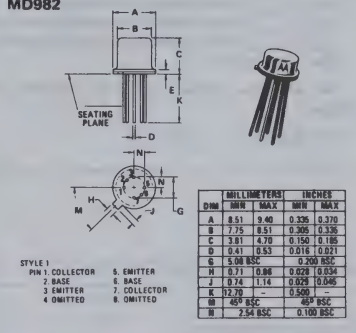
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	50		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD982		600	650	
MD982F		350	400	
MQ982		400	600	
Derate above 25°C				mW/°C
MD982		3.42	3.7	
MD982F		2.0	2.28	
MQ982		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD982		2.1	3.8	
MD982F		1.25	2.5	
MQ982		1.0	4.0	
Derate above 25°C				mW/°C
MD982		12	17.2	
MD982F		7.15	14.3	
MQ982		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD982		292	270	
MD982F		500	438	
MQ982		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD982		83.3	58.3	
MD982F		140	70	
MQ982		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD982		85	40	
MD982F		75	0	
MQ982 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD982

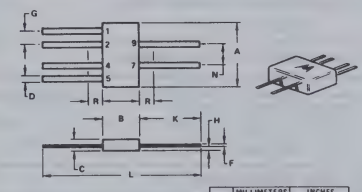


STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD982F

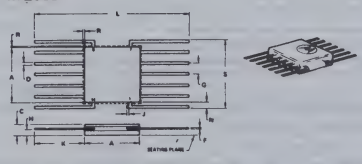


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ982



STYLE 1:
PIN
Q1 { 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
Q2 { 6. BASE
7. COLLECTOR
8. COLLECTOR
Q3 { 9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
Q4 { 13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
R	0.25	–	0.010	–
A	–	0.38	–	0.015
F	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$,

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})$ /4

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, $T_A = 150^oC$)	I_{CBO}	– –	– –	0.020 20	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 20 25 35 40	 50 75 90 60	 – – – –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.25	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.88	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	16	30	pF

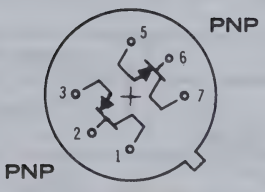
(1) Pulse Test: Pulse Width $\leq$300 μs, Duty Cycle $\leq$2.0%.

MD984 (SILICON)

PNP silicon annular dual transistor for high-speed switching and amplifier applications.



CASE 654-04



PINS 4 AND 8 OMITTED
PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation (25°C Case Temperature) Derate above 25°C	P_D	 1.6 9.1	 3.0 17.2	 W mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 0.5 2.9	 0.6 3.4	 W mW/°C

ELECTRICAL CHARACTERISTICS (each side)

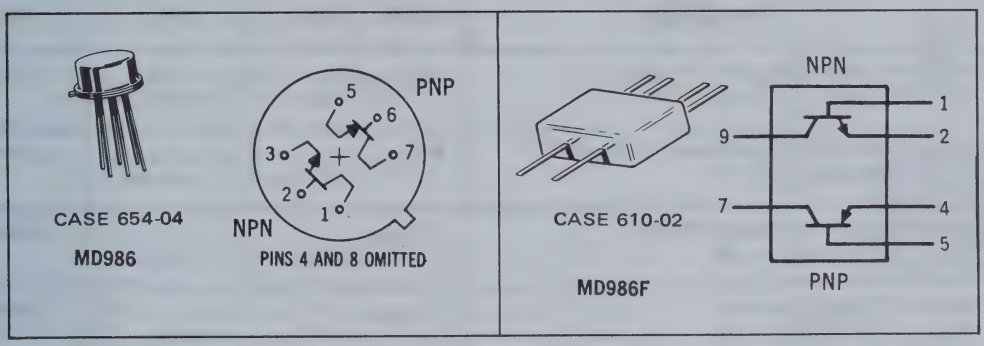
(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = -10 mAdc, I_B = 0)	BV_{CEO}	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc, I_C = 0)	BV_{EBO}	5.0	---	Vdc
Collector Cutoff Current (V_{CB} = -20 Vdc, I_E = 0) (V_{CB} = -20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	.025 30	μAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc) (I_C = -50 mAdc, I_B = -5 mAdc)	$V_{CE(sat)}$	--- ---	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	---	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = -10 mAdc, V_{CE} = -10 Vdc)	h_{FE}	25	---	---
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	---	4.0	pF
Small-Signal Forward Current Transfer Ratio (I_C = -20 mAdc, V_{CE} = -20 Vdc, f = 100 MHz)	h_{fe}	2.5	---	---
Current-Gain–Bandwidth Product (I_C = -20 mAdc, V_{CE} = -20 Vdc)	f_T	250	---	MHz

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

MD986, F (SILICON)

NPN-PNP silicon annular Star complementary pair dual transistors for high-speed switching circuits and DC to UHF amplifier applications.



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$	P_D			
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		—	30	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	4.0	pF
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc) TO-5 Package	f_T	200	—	MHz
(V_{CE} = 10 Vdc, I_C = 20 mAdc) Flat Package		200	—	

[1]Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2%

MD1120, MD1120F (SILICON)
MD1121
MD1122
MQ1120

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
  $\triangle|V_{BE1} - V_{BE2}|$ = 0.8 mVdc (Max) @ -55 to +25°C
  = 1.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 80 mVdc (Typ) @ I_C = 10 mAdc
- DC Current Gain Specified – 10 μAdc to 10 mAdc
- High Current-Gain-Bandwidth Product –
  f_T = 250 MHz @ I_C = 20 mAdc

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			
MD1120,MD1121,MD1122		575	625	mW
MD1120F		350	400	
MQ1120		400	600	
Derate Above 25°C				
MD1120,MD1121,MD1122		3.29	3.57	mW/°C
MD1120F		2.0	2.28	
MQ1120		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			
MD1120,MD1121,MD1122		1.8	2.5	Watts
MD1120F		1.0	2.0	
MQ1120		0.9	3.6	
Derate Above 25°C				
MD1120,MD1121,MD1122		10.3	14.3	mW/°C
MD1120F		5.71	11.4	
MQ1120		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

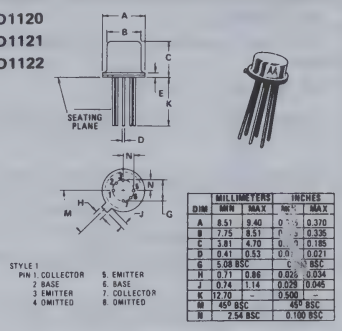
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD1120,MD1121,MD1122		304	280	
MD1120F		500	438	
MQ1120		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD1120,MD1121,MD1122		97	70	
MD1120F		175	87.5	
MQ1120		195	48.8	
		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
MD1120,MD1121,MD1122		84	44	
MD1120F		75	0	
MQ1120 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON MULTIPLE TRANSISTORS

MD1120
MD1121
MD1122

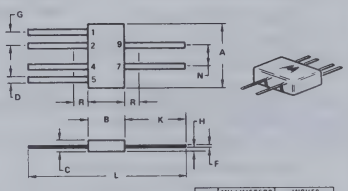


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

MD1120F

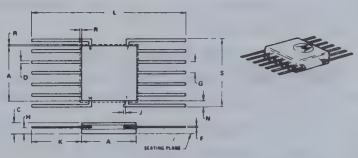


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89		0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

STYLE 1
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610-A03

MQ1120



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38		0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

STYLE 1
PIN
Q1: 1. COLLECTOR, 2. BASE, 3. EMITTER, 4. NOT CONNECTED
Q2: 5. EMITTER, 6. BASE, 7. COLLECTOR, 8. COLLECTOR
Q3: 9. BASE, 10. EMITTER, 11. NOT CONNECTED, 12. EMITTER
Q4: 13. BASE, 14. COLLECTOR

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifier to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$.

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})$ /4

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				nAdc
(V_{CB} = 50 Vdc, I_E = 0)		–	–	10	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 10 Vdc)		20	40	100	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		30	50	120	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	60	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	65	200	
Collector-Emitter Staruation Voltage (I_C = 10 mAdc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	80	100	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	700	850	mVdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
MATCHING CHARACTERISTICS (MD1120,MD1120F,MD1121 MD1122)					
DC Current Gain Ratio (2)	h_{FE1}/h_{FE2}				
(I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices		0.8	–	1.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122		0.9	–	1.0	
Base-Emitter Voltage Differential	$\lvert V_{BE1}/V_{BE2} \rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices		–	–	10	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122		–	–	5.0	
Base-Emitter Voltage Differential Change Due to Temperature – MD1121, MD1122	$\triangle\lvert V_{BE1}/V_{BE2} \rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C)		–	–	0.8	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)		–	–	1.0	

(1) Pulse test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1129 (SILICON)
MD1129F
MQ1129

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – MD1129,F
  $\triangle|V_{BE1} - V_{BE2}|$ = 0.8 mVdc (Max) @ -55 to +25°C
  = 1.0 mVdc (Max) @ +25°C to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.09 Vdc (Typ) @ I_C = 10 mAdc – MD1129,MQ1129
- DC Current Gain Specified at Low Collector Currents –
  h_{FE} = 60 (Min) @ I_C = 10 μAdc
- High Current-Gain-Bandwidth Product –
  f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

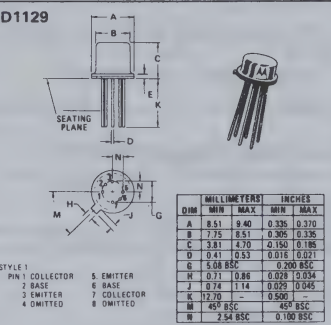
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		One Die	All Die	
Total Power Dissiaption @ T_A = 25°C	P_D			mW
MD1129		575	625	
MD1129F		350	400	
MQ1129		400	600	
Derate above 25°C				
MD1129		3.29	3.57	mW/°C
MD1129F		2.0	2.28	
MQ1129		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD1129		1.8	2.5	
MD1129F		1.0	2.0	
MQ1129		0.9	3.6	
Derate above 25°C				
MD1129		10.3	14.3	mW/°C
MD1129F		5.71	11.4	
MQ1129		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)			°C/W
MD1129		304	280	
MD1129F		500	438	
MQ1129		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD1129		97	70	
MD1129F		175	87.5	
MQ1129		195	48.8	
		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
MD1129		84	44	
MD1129F		75	0	
MQ1129 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

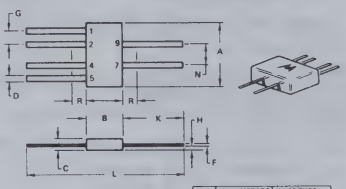
MD1129



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

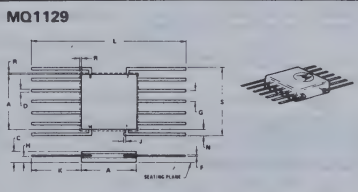
MD1129F



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610-A03

MQ1129



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
M	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.42	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$.

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 10 Vdc)		60	–	–	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		100	–	300	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		100	120	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		100	140	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) MD1129, MQ1129	$V_{CE(sat)}$	–	0.09	0.1	Vdc
MD1129F		–	–	0.15	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
MATCHING CHARACTERISTICS (MD1129, MD1129F)					
DC Current Gain Ratio (2)	h_{FE1}/h_{FE2}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		0.9	–	1.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		0.9	–	1.0	
Base-Emitter Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C 100 μAdc, V_{CE} = 10 Vdc)		–	–	5.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		–	–	5.0	
Base-Emitter Voltage Differential Change Due to Temperature	$\triangle\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C)		–	–	0.8	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)		–	–	1.0	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

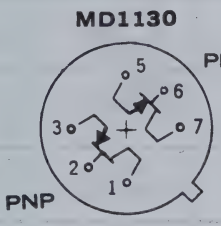
MD1130, F (SILICON)

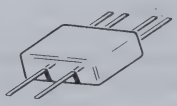
PNP silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



CASE 654-04

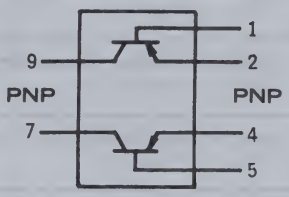
MD1130





CASE 610-02

MD1130F



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current (Limited by P_D)	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Flat Package Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 250 1.5	 350 2	 mW mW/°C
Metal Can Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 2.9	 600 3.4	 mW mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

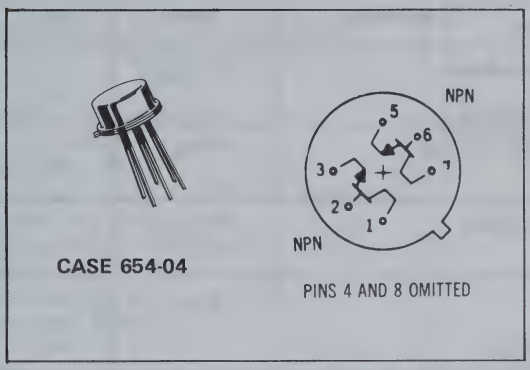
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc)	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = -10 mAdc)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = -50 Vdc)	I_{CBO}	-	.010	μAdc
(V_{CB} = -50 Vdc, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{EB} = -3 Vdc)	I_{EBO}	-	10	nAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = -10 μAdc, V_{CE} = -10 Vdc)		60	-	
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		100	300	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		100	-	
(I_C = -10 mAdc, V_{CE} = -10 Vdc)		100	-	
DC Current Gain Ratio**	h_{FE1}/h_{FE2}**			-
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		0.9	1.0	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		0.9	1.0	
Base Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		-	5.0	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		-	5.0	
Base Voltage Differential Change (I_C = -100 μAdc, V_{CE} = -10 Vdc, T_A = -55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	10	μV/°C
Collector Output Capacitance (V_{CB} = -10 Vdc, F = 100 kHz)	C_{ob}	-	4.0	pF
Current-Gain – Bandwidth Product (V_{CE} = -10 Vdc, I_C = -20 mAdc)	f_T	200	-	MHz

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1132 (SILICON)

NPN silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	30		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	300	400	mW
Derating Factor Above 25°C		1.7	2.3	mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 1 μAdc)	BV_{CBO}	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc) (V_{CB} = 15 Vdc, T_A = 150°C)	I_{CBO}	— —	.010 1.0	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	—	—
DC Current Gain Ratio* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE1}/h_{FE2}*	0.9	1.0	—
Base Voltage Differential (I_C = 1 mAdc, V_{CE} = 5 Vdc)	$\lvert V_{BE1}-V_{BE2} \rvert$	—	5.0	mVdc
Base Voltage Differential Change (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C) (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = +25 to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	10 10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 140 kHz) (V_{CB} = 0 Vdc, f = 140 kHz)	C_{ob}	— —	1.7 3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, f = 140 kHz)	C_{ib}	—	2.0	pF
Small Signal Forward Current Transfer Ratio (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	6.0	—	—

*The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD2218, MD2218A (SILICON)
MD2218F, MD2218AF
MD2219, MD2219A
MD2219F, MD2219AF
MQ2218, MQ2219A

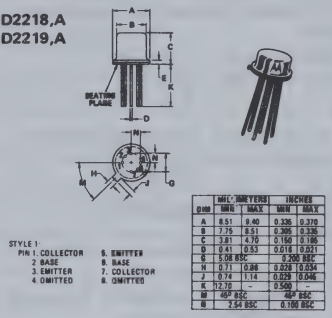
MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Fast Switching — MD2218A,AF, MD2219A,AF
  t_d = 15 μs (Max) t_r = 30 μs (Max)
  t_s = 250 μs (Max) t_f = 60 μs (Max)
- Low Collector-Emitter Saturation Voltage — MD2218AF, MD2219AF
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified — MD2218,A, MD2219,A
  0.1 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product
  f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS

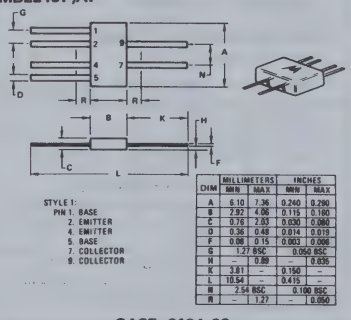
MD2218,A
MD2219,A



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

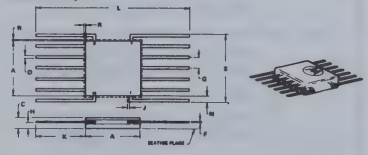
MD2218F,AF
MD2219F,AF



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ2218,A
MQ2219,A



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.80	0.240	0.270
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.36	–	0.015
K	3.35	–	0.260	–
L	10.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

MAXIMUM RATINGS

Rating	Symbol	MD2218,A,F MD2219,A,F MQ2218,A MQ2219,A	MD2218AF MD2219AF	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A=25°C	P_D			
MD2218,A,MD2219,A		575	625	mW
MD2218F,AF, MD2219F,AF		350	400	
MQ2218,A, MQ2219,A		400	600	
Derate Above 25°C				
MD2218,A,MD2219,A		3.29	3.57	mW/°C
MD2218F,AF,MD2219F,AF		2.0	2.28	
MQ2218,A,MQ2219,A		2.28	3.42	
Total Power Dissipation @ T_C=25°C	P_D			
MD2218,A,MD2219,A		1.8	2.5	Watts
MD2218F,AF,MD2219F,AF		1.0	2.0	
MQ2218,A,MQ2219,A		0.9	3.6	
Derate Above 25°C				
MD2218,A,MD2219,A		10.3	14.3	mW/°C
MD2218F,AF,MD2219F,AF		5.71	11.4	
MQ2218,A,MQ2219,A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2218,A,MD2219,A		304	280	
MD2218,F,AF,MD2219,F,AF		500	438	
MQ2218,A,MQ2219,A		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2218,A,MD2219,A		97	70	
MD2218F,AF,MD2219F,AF		175	87.5	
MQ2218,A,MQ2219,A		195	48.8	
		Junction to Ambient	Junction to Case	
Coupling Factors				
MD2218,A,MD2219,A		84	44	%
MD2218F,AF,MD2219F,AF		75	0	
MQ2218,A,MQ2219,A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$.

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})$ /4

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}				Vdc
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		30	–	–	
MD2218AF, MD2219AF		40	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}				Vdc
MD2218,A,F,MD2219,A,F,MQ2218,A,MD2219,A		60	–	–	
MD2218AF, MD2219AF		75	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}				Vdc
MD2218,A,F, MD2219,A.F. MQ2218,A, MQ2219,A		5.0	–	–	
MD2218AF, MD2219AF		6.0	–	–	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}				nAdc
MD2218,F,MD2219,F,MQ2218,A		20	–	–	
MD2218A,AF,MD2219A,AF,MQ2219,A		15	–	–	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	30	–	–	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		20	50	–	
MD2219,A,F,AF,MQ2219,A		35	45	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		25	55	–	
MD2219,A,F,AF,MQ2219,A		50	55	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		35	65	–	
MD2219,A,F,AF,MQ2219,A		75	85	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)					
MD2218,A,F,AF,MQ2218,A		20	65	–	
MD2219,A,F,AF,MQ2219,A		50	65	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		40	30	120	
MD2219,A,F,AF,MQ2219,A		100	120	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,MQ2218,A		25	75	–	
MD2219,A,MQ2219,A		30	75	–	

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued) (1)					
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$				Vdc
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	0.2	0.4	
MD2218AF, MD2219AF		–	–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	0.35	1.2	
MD2218AF,MD2219AF		–	–	0.9	
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$				Vdc
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		0.6	0.95	1.3	
MD2218AF,MD2219AF		0.6	1.0	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	–	2.0	
MD2218AF,MD2219AF		–	–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}				pF
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	15	30	
MD2218AF,MD2219AF		–	18	25	
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = 15 mAdc) (Figure 11) MD2218,F,MD2219,F	t_d	–	–	20	μs
MD2218A,AF,MD2219A,AF		–	–	15	
Rise Time MD2218,F,MD2219,F	t_r	–	–	40	μs
MD2218A,AF,MD2219A,AF		–	–	30	
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 12) MD2218,F,MD2219,F	t_s	–	–	280	μs
MD2218A,AF,MD2219A,AF		–	–	250	
Fall Time MD2218,F,MD2219,F	t_f	–	–	70	μs
MD2218A,AF,MD2219A,AF		–	–	60	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

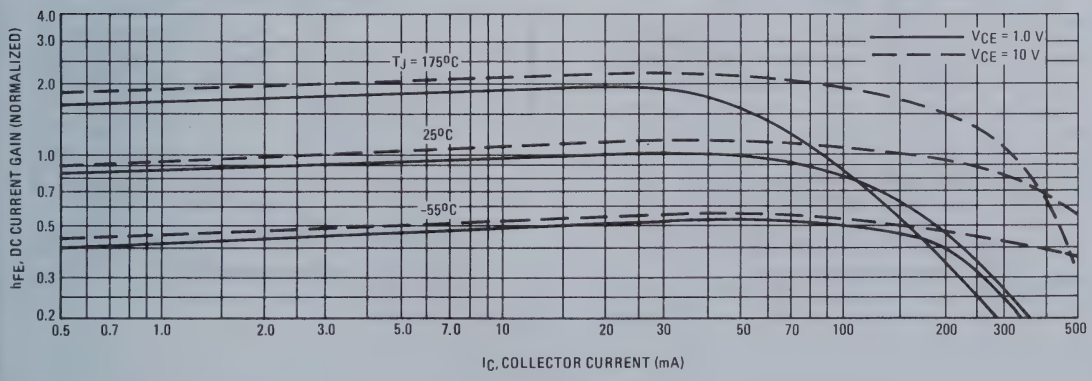


FIGURE 2 – "ON" VOLTAGES

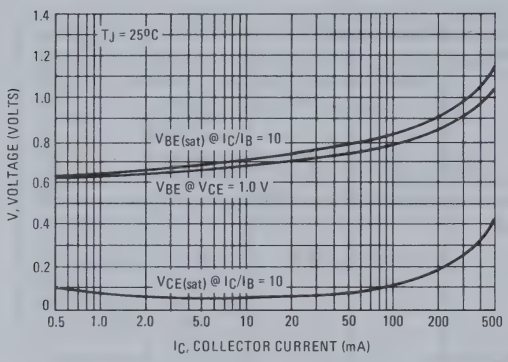
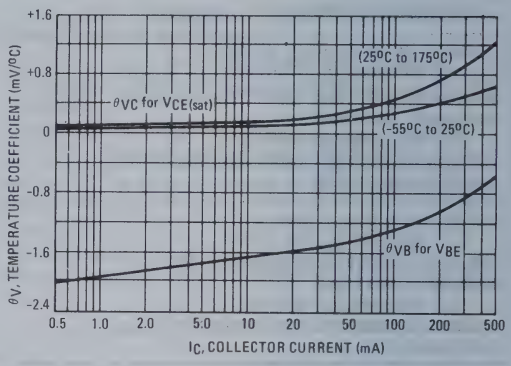


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

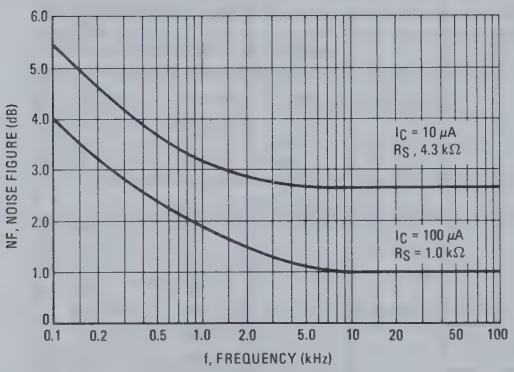


FIGURE 5 – SOURCE RESISTANCE EFFECTS

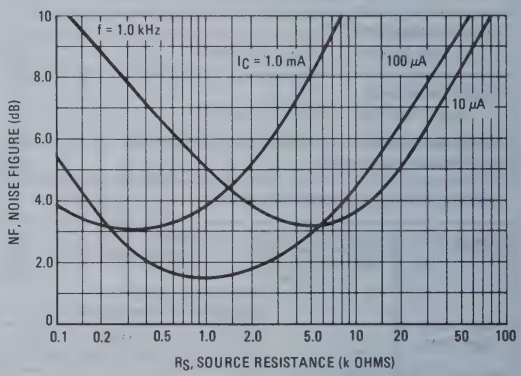


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

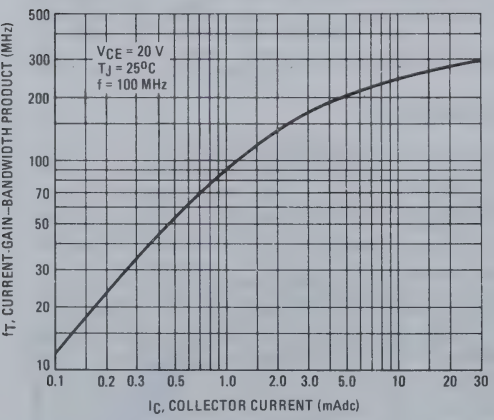
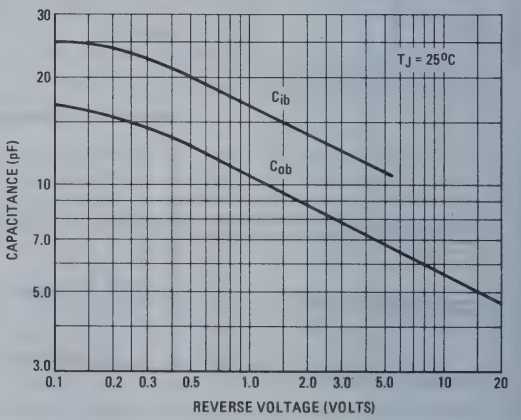


FIGURE 7 – CAPACITANCES



SWITCHING TIME CHARACTERISTICS

FIGURE 8 – TURN-ON TIME

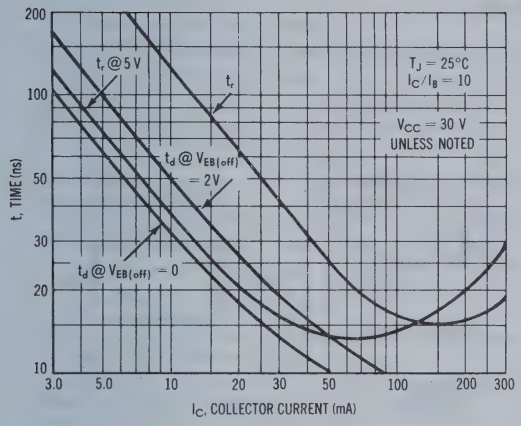


FIGURE 9 – CHARGE DATA

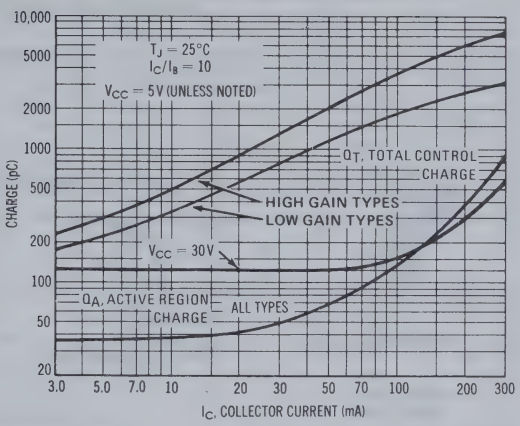
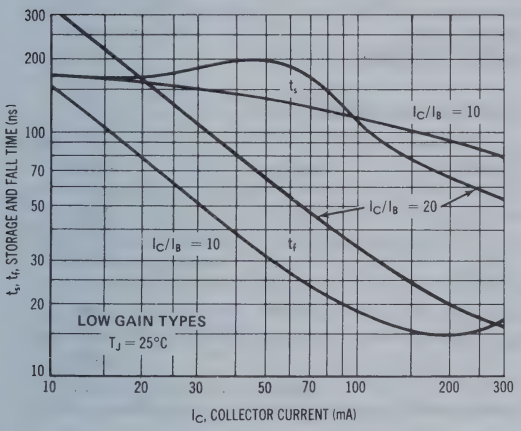


FIGURE 10 – TURN-OFF BEHAVIOR



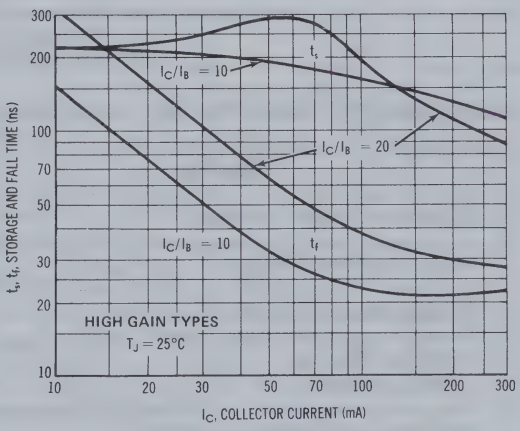


FIGURE 11 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

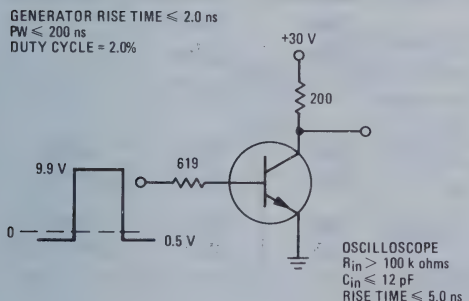
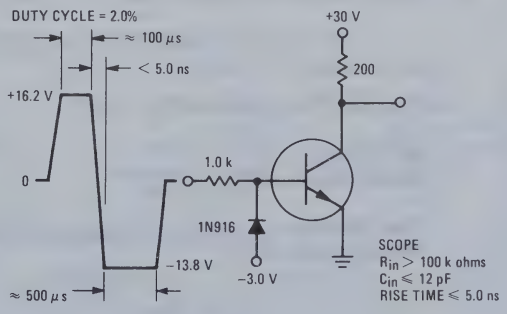


FIGURE 12 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



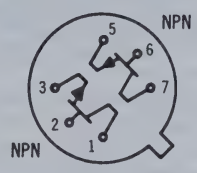
MD2369, F (SILICON)
MD2369A, F

Dual NPN silicon annular transistors designed for high-speed, logic switching and space saving considerations. Matched pairs are available for differential amplifier applications.

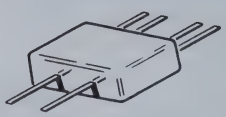


CASE 654-04

MD2369
MD2369A

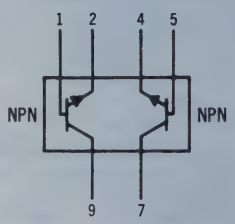


PINS 4 AND 8 OMITTED



CASE 610-02

MD2369F
MD2369AF



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current (10 μs Pulse)	I_C	500		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5 0	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.03	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)		—	30	
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	140	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 MHz)	C_{ib}	—	4.0	pF
Charge Storage Time Constant (Figure 3)	t_s	—	13	ns
Turn-On Time (Figure 1)	t_{on}	—	15	ns
Turn-Off Time (Figure 2)	t_{off}	—	20	ns
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 3 mAdc, V_{CE} = 1 Vdc) MD2369A, MD2369AF	h_{FE1}/h_{FE2}	0.9	1.0	—
Base Voltage Differential (I_C = 3 mAdc, V_{CE} = 1 Vdc) MD2369A, MD2369AF	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5.0	mVdc
Base Voltage Differential Gradient (I_C = 3 mAdc, V_{CE} = 1 Vdc, T_A = -55 to +125°C) MD2369A, MD2369AF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C

[1] Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%
**The lowest h_{FE} reading is taken as h_{FE1} for this test.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA

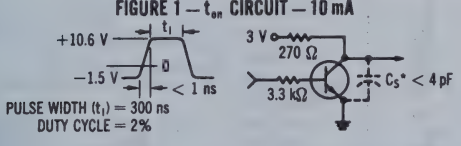


FIGURE 2 — t_{off} CIRCUIT — 10 mA

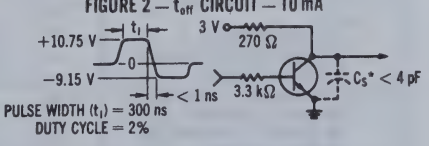
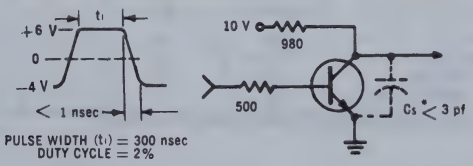


FIGURE 3 — STORAGE TIME EQUIVALENT TEST CIRCUIT



MD2904, MD2904A (SILICON)
MD2904F, MD2904AF
MD2905, MD2905A
MD2905F, MD2905AF
MQ2904, MQ2905A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- Fast Switching Times –
  t_{on} = 45 ns (Max) and t_{off} = 130 ns (Max)
- DC Current Gain Specified –
  0.1 mAdc to 500 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 320 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

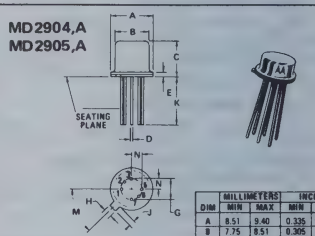
Rating	Symbol	MD2904,F MD2905,F MQ2904	MD2904A,AF MD2905A,AF MQ2905A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD2904,A, MD2905,A		575	625	
MD2904F,AF, MD2905F,AF		350	400	
MQ2904, MQ2905A		400	600	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		3.29	3.57	
MD2904,F,AF, MD2905F,AF		2.0	2.28	
MQ2904, MQ2905A		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD2904,A, MD2905,A		1.8	2.5	
MD2904F,AF, MD2905F,AF		1.0	2.0	
MQ2904, MQ2905A		0.9	3.6	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		10.3	14.3	
MD2904F,AF, MD2905F,AF		5.71	11.4	
MQ2904, MQ2905A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2904,A, MD2905,A		304	280	
MD2904F,AF, MD2905F,AF		500	438	
MQ2904, MQ2905A		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2904,A, MD2905,A		97	70	
MD2904F,AF, MD2905F,AF		175	87.5	
MQ2904, MQ2905A		195	48.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD2904,A, MD2905,A		84	44	
MD2904F,AF, MD2905F,AF		75	0	
MQ2904, MQ2905A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD2904,A
MD2905,A

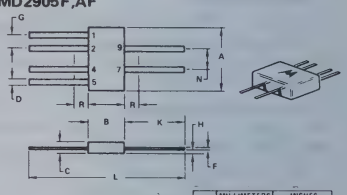


DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

MD2904F,AF
MD2905F,AF

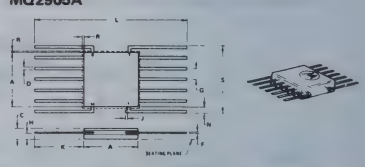


DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H		0.89		0.035
K	3.81		0.150	–
L	10.54		0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

STYLE 1
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

MQ2904
MQ2905A



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.88	0.005	0.035
J		0.38		0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
M	0.25	–	0.010	–
R	–	0.38		0.015
S	7.62	8.38	0.300	0.330

STYLE 1
PIN
Q1: 1 COLLECTOR, 2 BASE, 3 EMITTER
4 NOT CONNECTED
Q2: 5 EMITTER, 6 BASE, 7 COLLECTOR
Q3: 8 COLLECTOR, 9 BASE, 10 EMITTER
11 NOT CONNECTED
Q4: 12 EMITTER, 13 BASE, 14 COLLECTOR

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$,

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)
(Characteristics apply to corresponding flat package, and quad type number.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MD2904, MD2905		40	–	–	
	MD2904A, MD2905A		60	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}	60	–	–	Vdc
(I_C = 10 μAdc, I_E = 0)						
Emitter-Base Breakdown Voltage		BV_{EBO}	5.0	–	–	Vdc
(I_E = 10 μAdc, I_C = 0)						
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)			–	–	0.020	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	30	
Emitter Cutoff Current		I_{EBO}	–	–	30	nAdc
(V_{BE} = 3.0 Vdc, I_C = 0)						
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904		20	50	–	
	MD2904A		40	70	–	
	MD2905		35	70	–	
	MD2905A		75	150	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	75	–	
	MD2904A		40	75	–	
	MD2905		50	100	–	
	MD2905A		100	175	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	90	–	
	MD2904A		40	90	–	
	MD2905		75	110	–	
	MD2905A		100	200	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2904,A,		40	90	120	
	MD2905,A		100	200	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2904		20	60	–	
	MD2904A		40	80	–	
	MD2905		30	130	–	
	MD2905A		50	150	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.25	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.88	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	2.6	

Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

ELECTRICAL CHARACTERISTICS (continued)

DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	16	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	t_{on}	–	–	45	ns
Delay Time	I_C = 150 mAdc,	t_d	–	–	12	ns
Rise Time	I_{B1} = 15 mAdc) (Figure 12)	t_r	–	–	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc,	t_{off}	–	–	130	ns
Storage Time	I_C = 150 mAdc,	t_s	–	–	100	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc) (Figure 13)	t_f	–	–	40	ns

FIGURE 1 – DC CURRENT GAIN

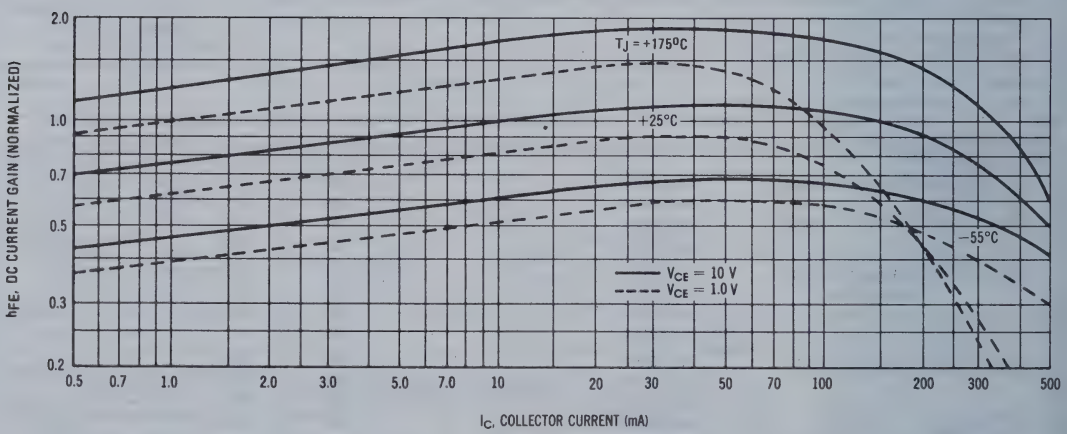


FIGURE 2 – "ON" VOLTAGES

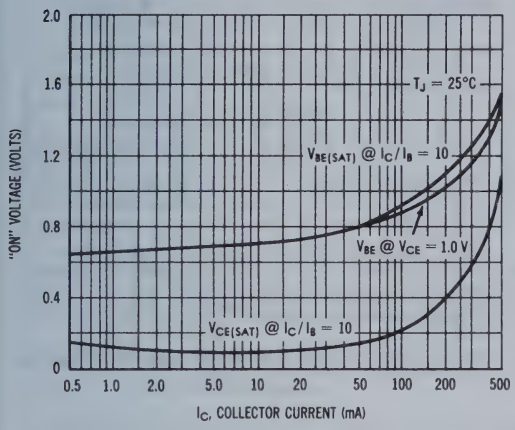
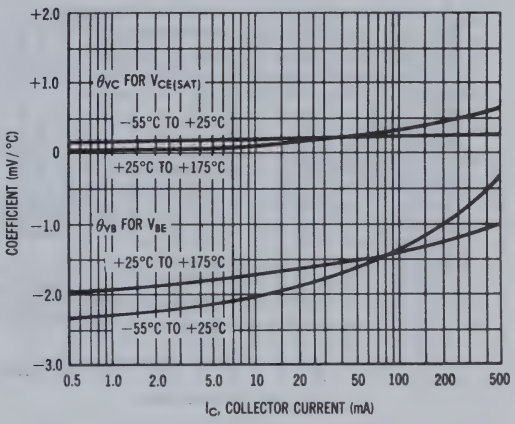


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 4 – FREQUENCY EFFECTS

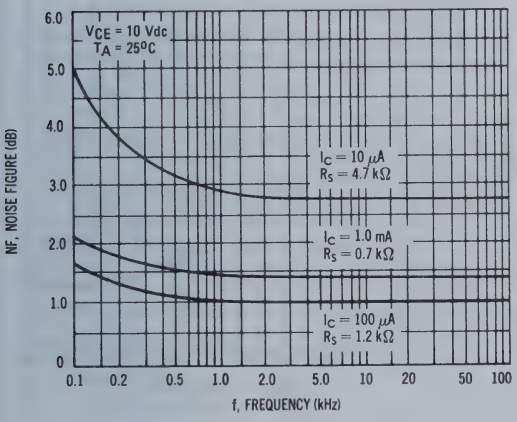


FIGURE 5 – SOURCE RESISTANCE EFFECTS

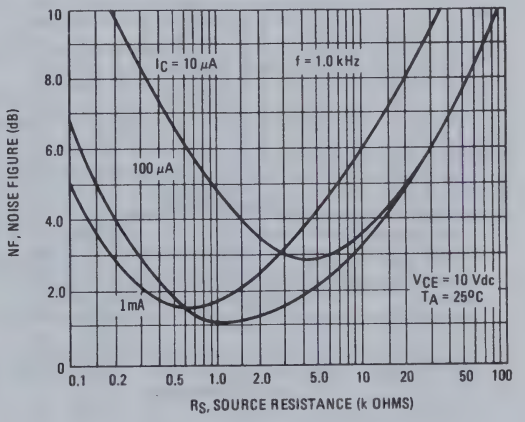


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

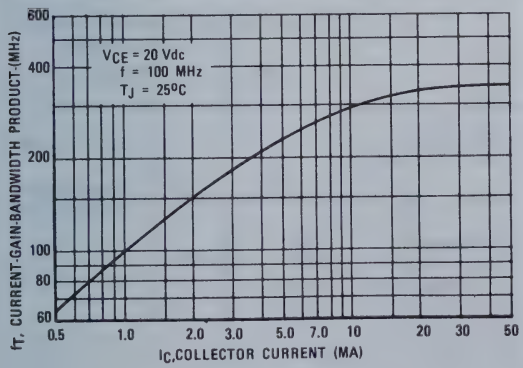


FIGURE 7 – CAPACITANCE

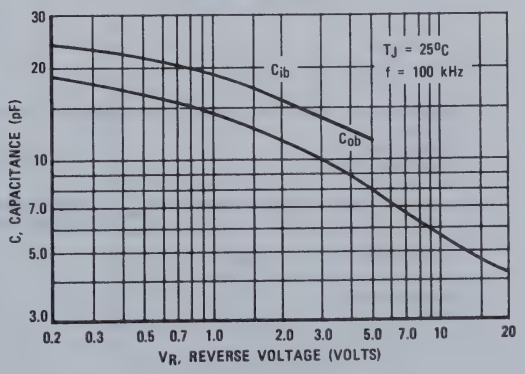


FIGURE 8 – TURN ON TIME

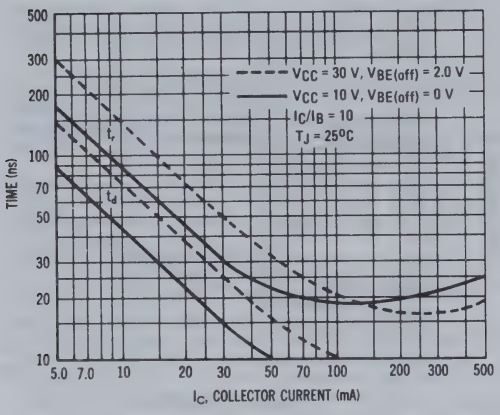


FIGURE 9 – CHARGE DATA

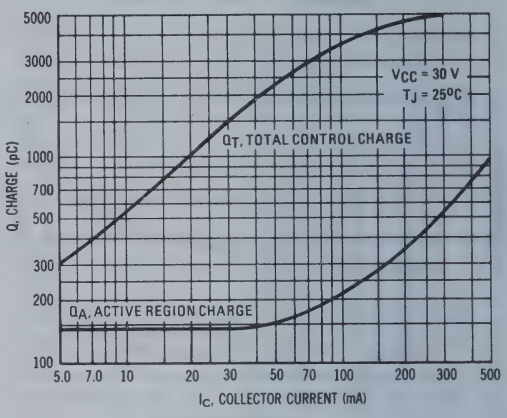


FIGURE 10 – STORAGE TIME

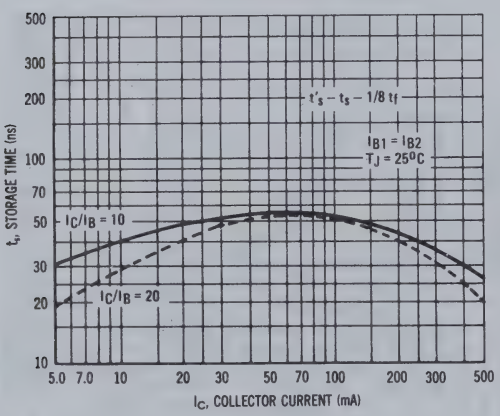


FIGURE 11 – FALL TIME

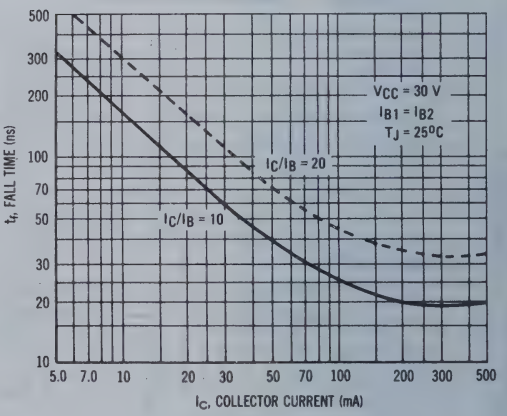


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

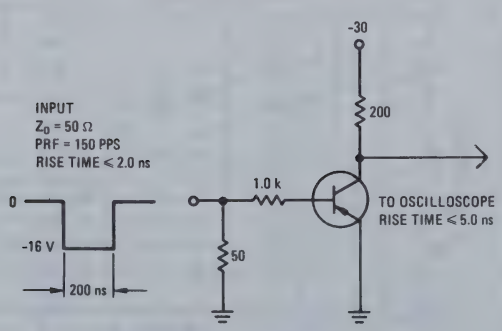
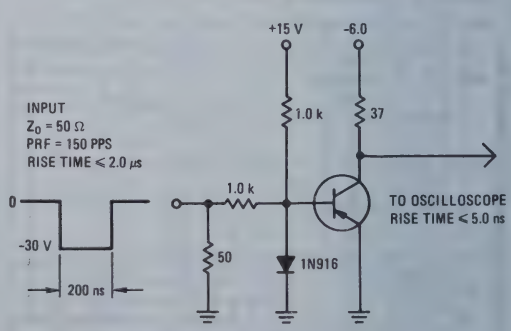
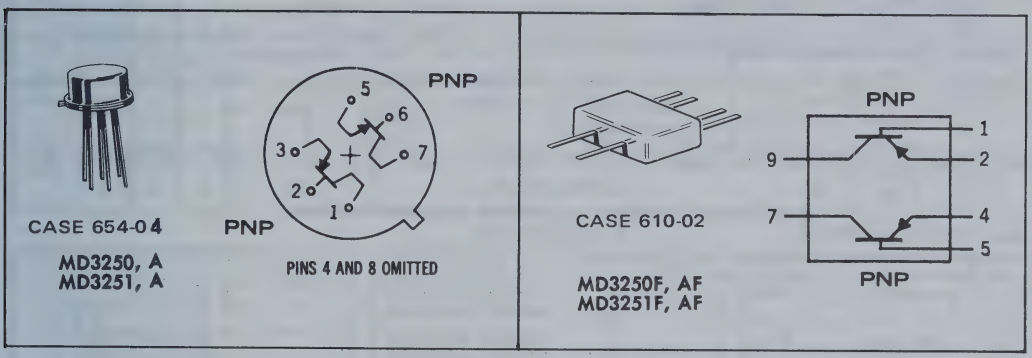


FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT



MD3250, A, F, AF (SILICON)
MD3251, A, F, AF

Dual PNP silicon annular transistors, especially designed for low-level, differential amplifier applications.



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	50		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
DC Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Pack		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
Metal Can		1.2	2.0	W
Derate above 25°C		6.85	11.42	mW/°C

MD3250, A,F,AF and MD3251, A,F,AF (continued)

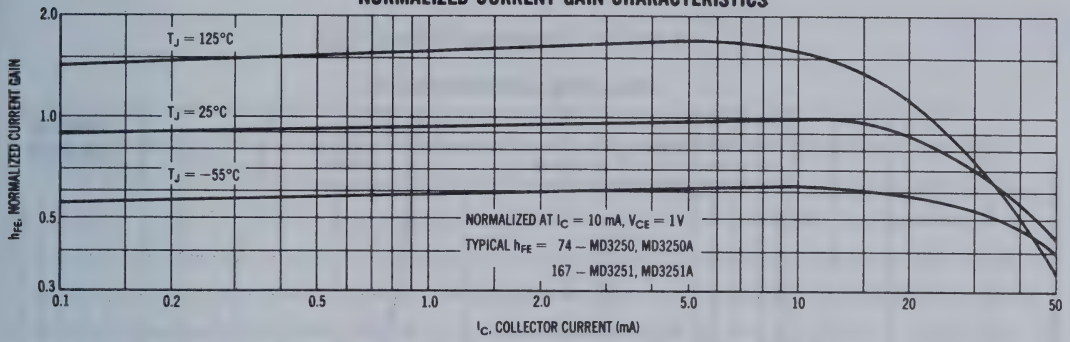
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40		—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	—	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Forward Current Transfer Ratio [1] (I_C = 10 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A	h_{FE}	25	—	—	—
	MD3251, MD3251A		50	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	MD3250, MD3250A		25	—	—	
	MD3251, MD3251A		50	—	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	—	
	MD3251, MD3251A		100	—	—	
(I_C = 50 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		15	—	—	
	MD3251, MD3251A		30	—	—	
Collector-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	0.50	
Base-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.6	—	0.9	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	1.2	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD3250, MD3250A	f_T	200	—	—	MHz
	MD3251, MD3251A		250	—	—	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	8.0	pF
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{fe}	50	—	200	—
	MD3251, MD3251A		100	—	400	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{re}	—	—	10	X10-4
	MD3251, MD3251A		—	—	20	
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{ie}	1.0	—	6.0	kohms
	MD3251, MD3251A		2.0	—	12	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{oe}	4.0	—	40	μmhos
	MD3251, MD3251A		10	—	60	
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_g = 3 kohm, Noise Bandwidth 10 cps to 15.7 kHz)	MD3250, MD3250A	NF	—	—	4.0	dB
	MD3251, MD3251A		—	—	3.0	
MATCHING CHARACTERISTICS (Types MD3250A and MD3251A only)						
DC Current Gain Ratio** (I_C = 100 μAdc and 1 mAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A	h_{FE1}/h_{FE2}**	0.9	—	1.0	—
Base Voltage Differential (I_C = 10 μA, to 10 mA, V_{CE} = 5 Vdc)	MD3250A, MD3251A	$\lvert V_{BE1}-V_{BE2}\rvert$	—	—	5.0	mVdc
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A		—	—	3.0	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C)	MD3250A, MD3251A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	—	10	mV/°C
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	MD3250A, MD3251A		—	—	10	

[1] Pulse Test ≤ 300 μs, duty cycle ≤ 2%

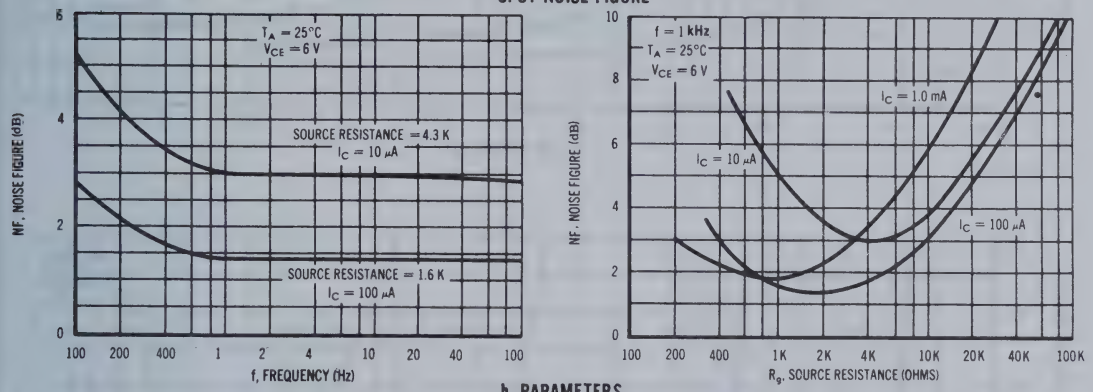
** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

NORMALIZED CURRENT GAIN CHARACTERISTICS



AUDIO SMALL SIGNAL CHARACTERISTICS

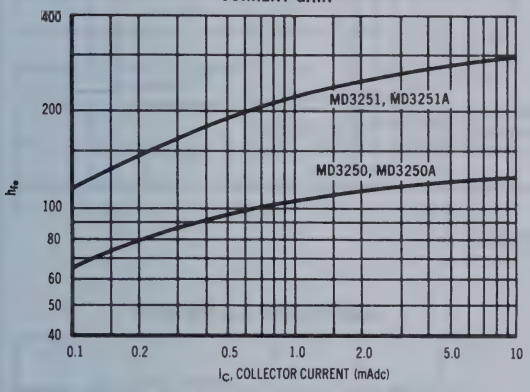
SPOT NOISE FIGURE



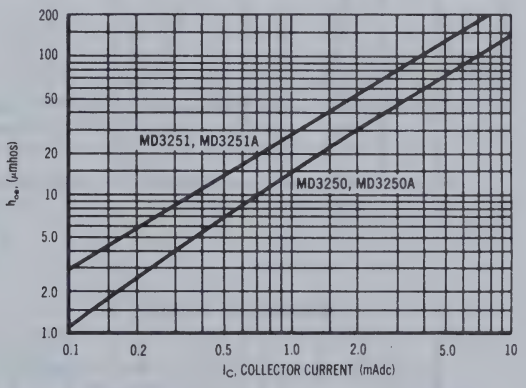
h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

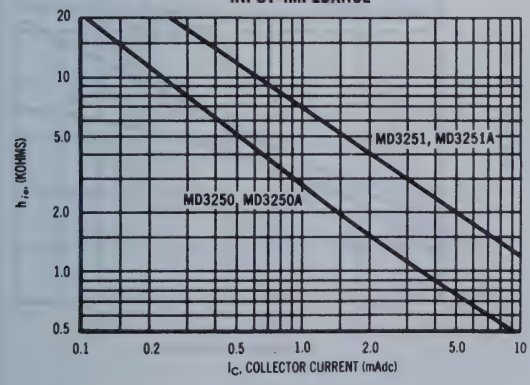
CURRENT GAIN



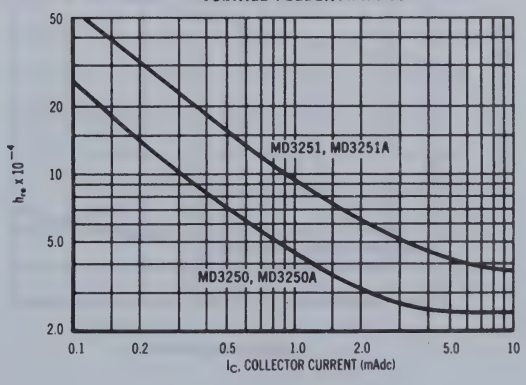
OUTPUT ADMITTANCE



INPUT IMPEDANCE

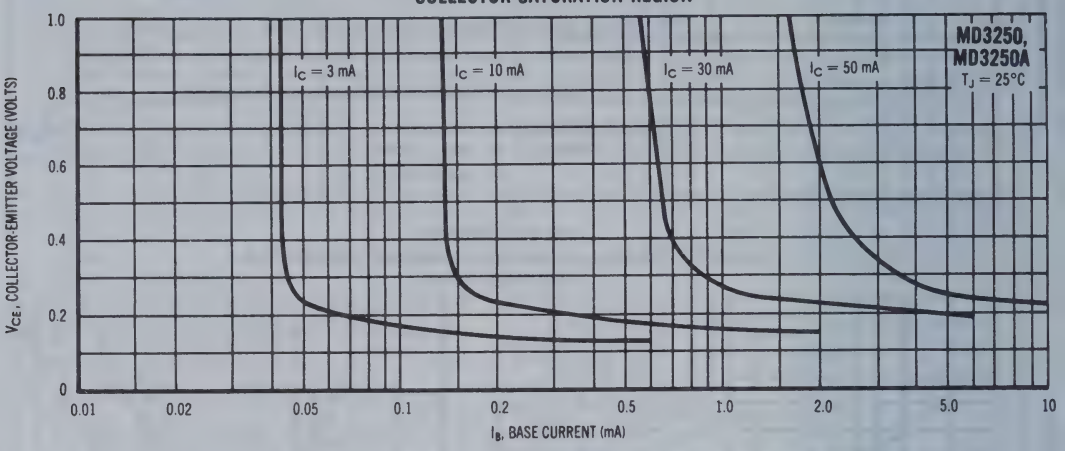


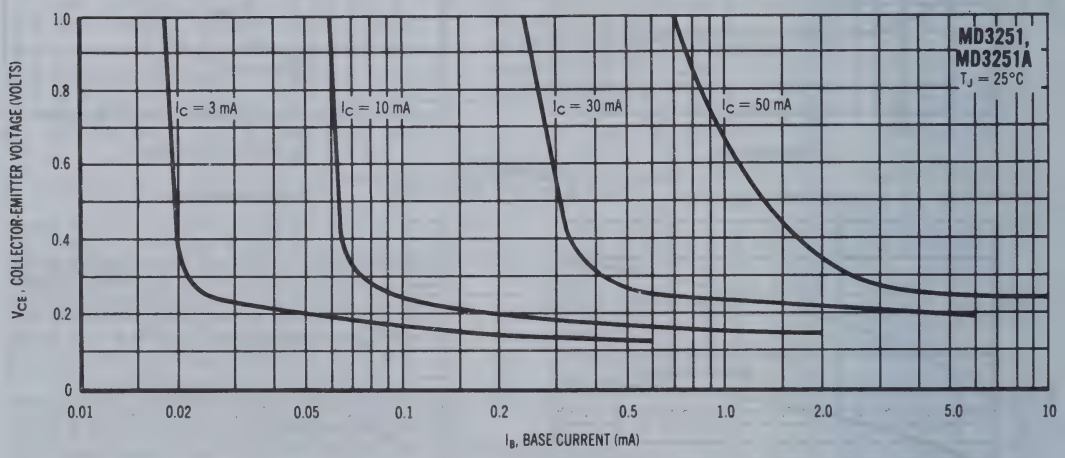
VOLTAGE FEEDBACK RATIO



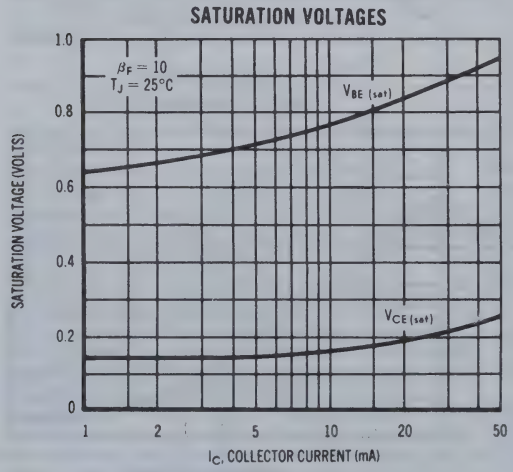
STATIC CHARACTERISTICS

COLLECTOR SATURATION REGION

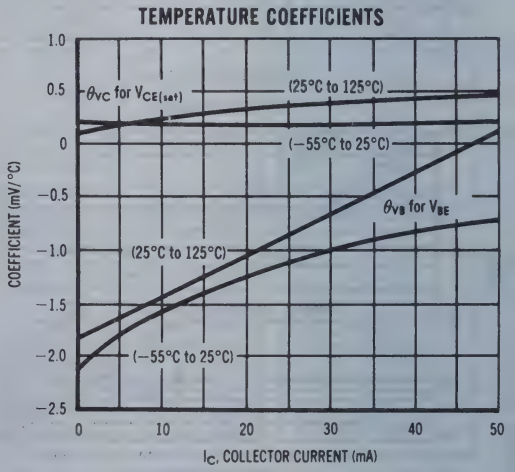




SATURATION VOLTAGES



TEMPERATURE COEFFICIENTS



MD3409 (SILICON)
MD3410

NPN SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – MD3410 –
  $\triangle|V_{BE1}-V_{BE2}|$ = 0.8 mVdc (Max) @ T_A = –55 to +25°C
  = 1.0 mVdc (Max) @ T_A = +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.15 Vdc (Max) @ I_C = 10 mAdc
- Low DC Current Gain –
  h_{FE} = 20-100 @ I_C = 10 μAdc – MD3410
- High Current-Gain–Bandwidth Product –
  f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS



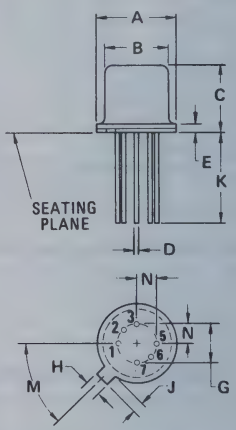
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector-Current	I_C	500		mAdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	–65 to +200		°C
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watt mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$K_{\theta 2}$ is the thermal coupling between die 1 and die 2.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to:

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2} = P_{DT} = 2 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in:

(4) $R_{\theta(EFF)} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu Adc, I_B = 0$)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc, I_E = 0$)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc, I_C = 0$)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
($V_{CB} = 50$ Vdc, $I_E = 0$)			–	–	10	nAdc
($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150^oC$)			–	–	10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				–
($I_C = 10\ \mu Adc, V_{CE} = 10$ Vdc)	MD3410		20	40	100	
($I_C = 100\ \mu Adc, V_{CE} = 10$ Vdc)	Both Devices		30	50	120	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)	Both Devices		40	60	160	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	Both Devices		50	65	200	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{CE(sat)}$	–	0.09	0.15	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		$V_{BE(sat)}$	–	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	200	250	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)		C_{ob}	–	3.5	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)		C_{ib}	–	15	25	pF
MATCHING CHARACTERISTICS						
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
($I_C = 100\ \mu Adc, V_{CE} = 10$ Vdc,	MD3409		–	–	1.6	
$T_A = -55^oC$ to $+25^oC$)	MD3410		–	–	0.8	
($I_C = 100\ \mu Adc, V_{CE} = 10$ Vdc,	MD3409		–	–	2.0	
$T_A = +25^oC$ to $+125^oC$)	MD3410		–	–	1.0	

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$

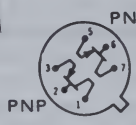
MD3467 (SILICON)
MD3467F
MQ3467

Dual and quad PNP silicon annular transistors designed for medium-current, high-speed switching and driver applications where space reduction is required.

MD3467



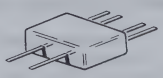
CASE 654-04



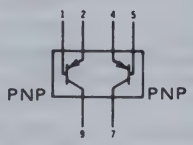
Pins 4 and 8 omitted

Pin connections, bottom view

MD3467F



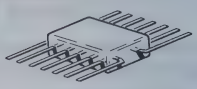
CASE 610-02



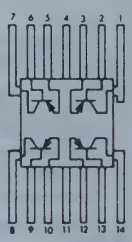
Pin connections, bottom view

Lead 1 identified by square impression on underside of case.

MQ3467



CASE 607



Lead 1 identified by color dot or by elbow on lead.

All leads isolated from case

MAXIMUM RATINGS (each transistor)

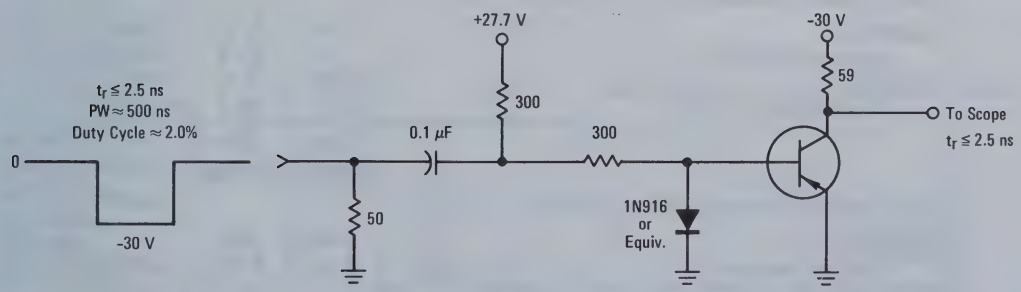
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3467		500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
MD3467F		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3467		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3467F		1.25	2.5	Watts
Derate above 25°C		7.15	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3467		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3467		1.25	5.0	
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	40	-	-
Collector-Emitter Saturation Voltage (1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	-	0.35	0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	-	0.9	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain —Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Collector-Emitter Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	-	30	80	ns
Fall Time		t_f	-	16	30	ns

(1) Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



MD3725 (SILICON)
MD3725F
MQ3725

MD3725



CASE 654-04



Pin Connections, Bottom View

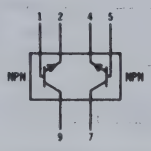
All leads isolated from case

Dual and quad NPN silicon annular transistors designed for medium-current, high-speed switching and driver applications where space reduction is required.

MD3725F



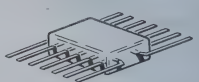
CASE 610-02



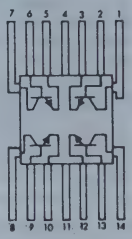
Pin Connections, Bottom View

Lead 1 identified by square impression or dot on underside of case
All leads isolated from case

MQ3725



CASE 607



Lead 1 identified by color dot or by elbow on lead.
All leads electrically isolated from package.

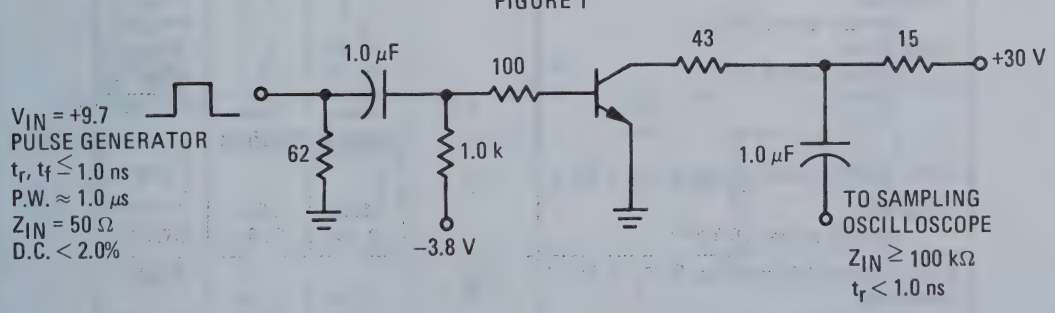
MAXIMUM RATINGS (each transistor)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	65		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current - Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3725		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD3725F		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3725		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3725F		1.25	2.5	Watts
Derate above 25°C		7.1	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3725		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3725		1.25	5.0	
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	65	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	- -	1.7 120	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50 30	150 -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	- -	0.26 0.52	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	- 0.85	0.86 1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	55	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	-	45	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	-	75	ns

FIGURE 1



MD3762 (SILICON)
MD3762F
MQ3762

Dual and quad PNP silicon annular transistors designed for high-current, high-speed switching and driver applications where space reduction is required.

MD3762



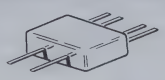
CASE 654-04



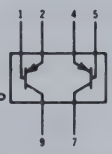
Pins 4 and 8 omitted

Pin connections, bottom view

MD3762F



CASE 610-02



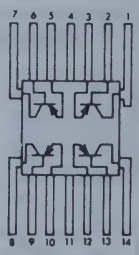
Pin connections, bottom view

Lead 1 identified by square impression on underside of case.

MQ3762



CASE 607



Lead 1 identified by color dot or by elbow on lead.

All leads isolated from case

MAXIMUM RATINGS (each transistor)

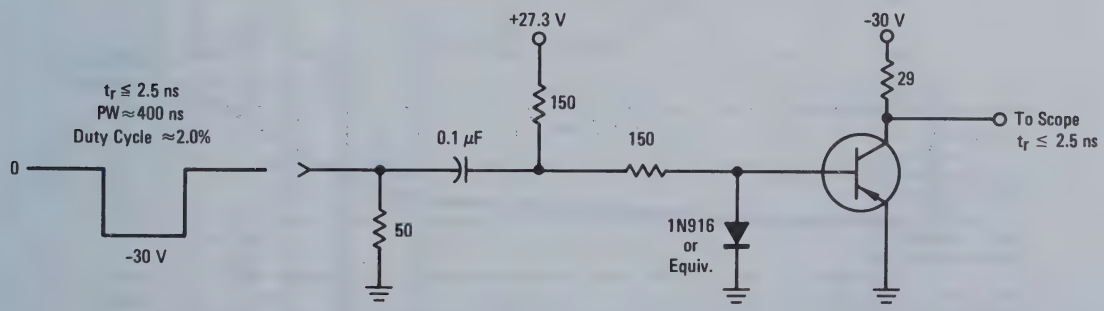
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	1.5		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3762		500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
MD3762F		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3762		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3762F		1.25	2.5	Watts
Derate above 25°C		7.15	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3762		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3762		1.25	5.0	
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
ON CHARACTERISTICS					
DC Current Gain [1] (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	40	-	-
Collector-Emitter Saturation Voltage [1] (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	-	0.7	1.0	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	-	1.1	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)	t_s	-	30	80	ns
Fall Time		t_f	-	16	30	ns

[1] Pulse test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT

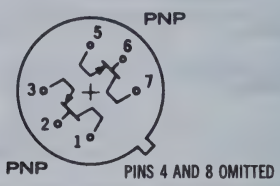


MD4957 (SILICON)



CASE 654-04

Dual PNP silicon annular 450-MHz amplifier designed for high-gain, low-noise amplifier, oscillator, and mixer applications.



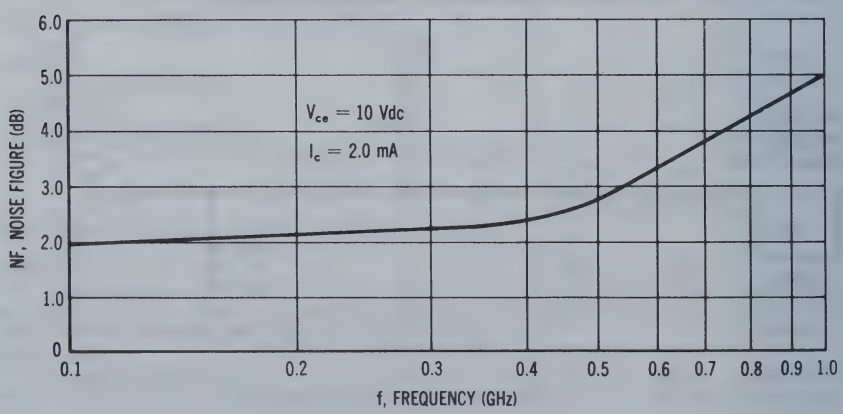
Pin Connections, Bottom View

All leads electrically isolated from case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	200	400	mW
Derate above 25°C		1.15	2.3	mW/°C

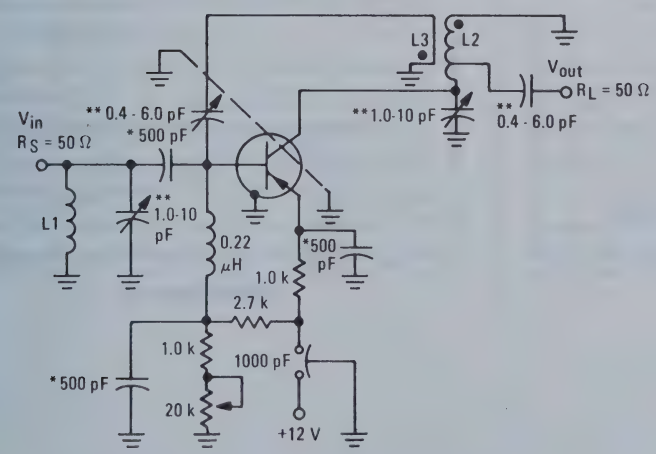
TYPICAL NOISE FIGURE vs. FREQUENCY



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	-	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	150	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	1500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	-	200	-
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_c$	-	4.0	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) Figure 1	NF	-	2.6	-	dB
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 GHz)		-	5.0	-	
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	-	18	-	dB
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_S = 50 ohms, f = 1.0 GHz)		-	13	-	

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors
** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (All type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

COMMON EMITTER Y PARAMETER VARIATIONS

Y PARAMETERS VS FREQUENCY

V_{CE} = 10 Vdc

I_C = 2.0 mA

FIGURE 2 — INPUT ADMITTANCE

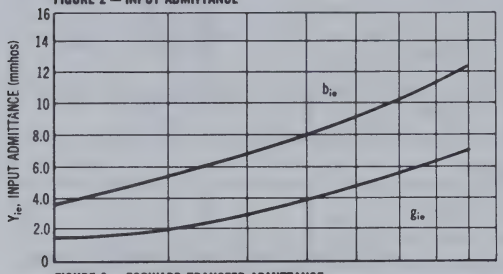


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

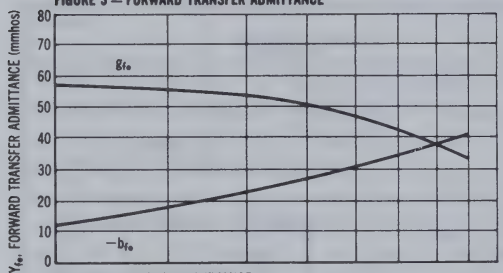


FIGURE 4 — OUTPUT ADMITTANCE

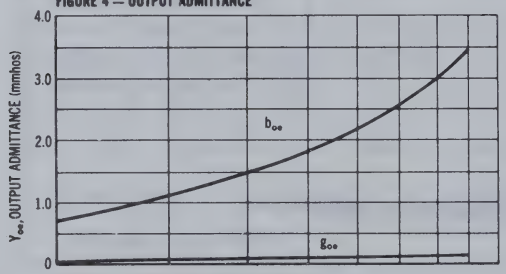
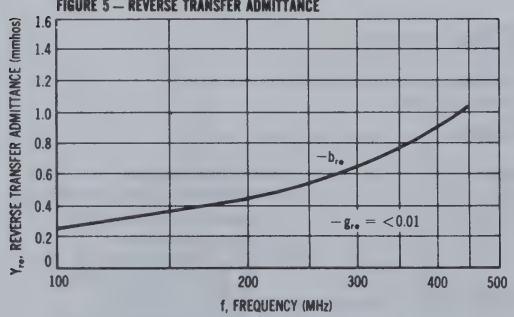


FIGURE 5 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS VS CURRENT

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

f = 450 MHz

FIGURE 6 — INPUT ADMITTANCE

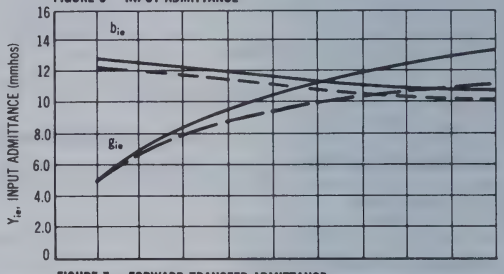


FIGURE 7 — FORWARD TRANSFER ADMITTANCE

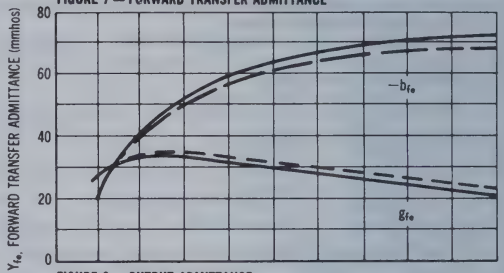


FIGURE 8 — OUTPUT ADMITTANCE

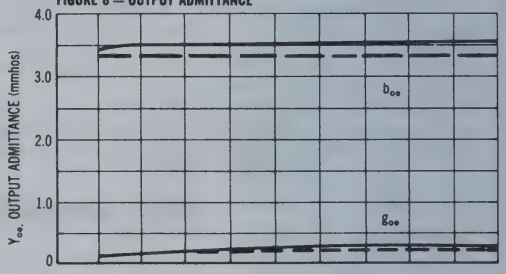
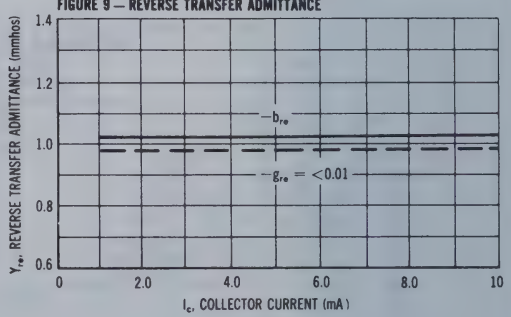


FIGURE 9 — REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

V_{CB} = 10 Vdc

I_C = 2.0 mA

FIGURE 10 — INPUT ADMITTANCE

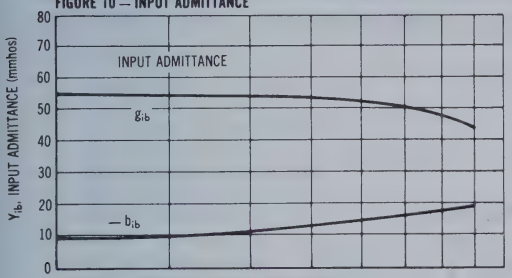


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

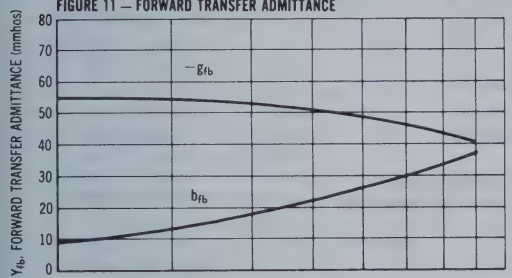


FIGURE 12 — OUTPUT ADMITTANCE

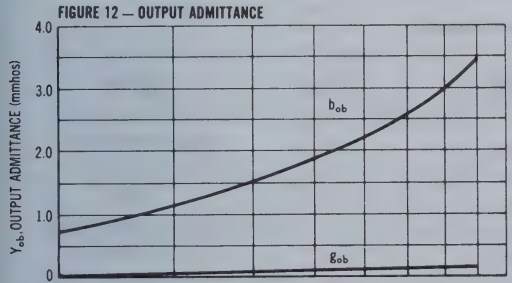
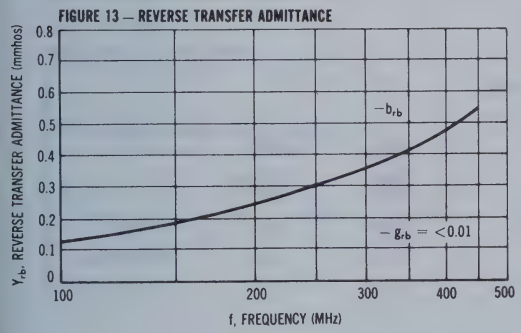


FIGURE 13 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

V_{CB} = 10 Vdc —— V_{CB} = 15 Vdc — — —

f = 450 MHz

FIGURE 14 — INPUT ADMITTANCE

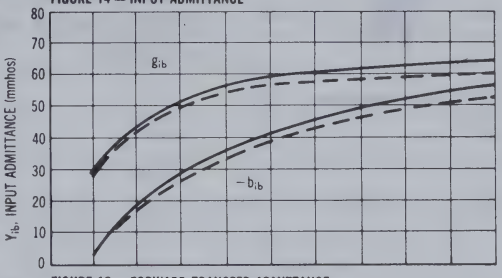


FIGURE 15 — FORWARD TRANSFER ADMITTANCE

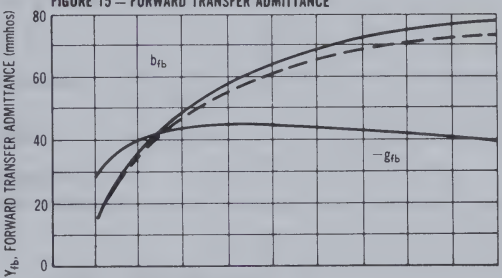


FIGURE 16 — OUTPUT ADMITTANCE

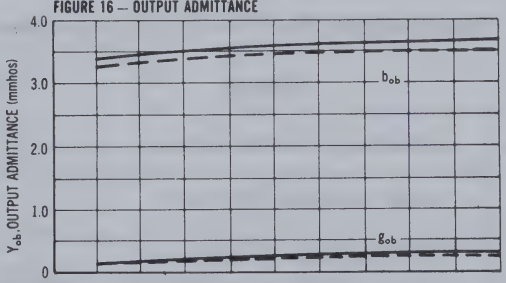
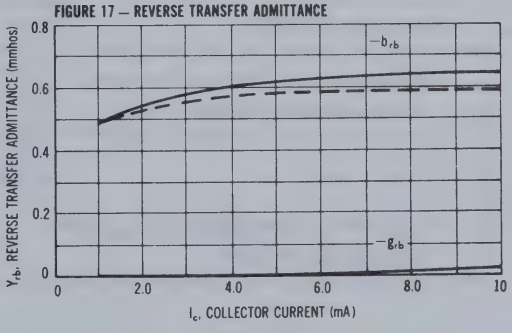


FIGURE 17 — REVERSE TRANSFER ADMITTANCE

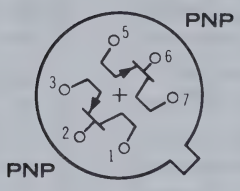


MD5000, A, B (SILICON)



CASE 654-04

Dual PNP silicon annular transistors designed for ultra-high frequency oscillator and amplifier applications and for differential-amplifier applications requiring a matched pair of transistors with a high degree of parameter uniformity under varying environmental conditions.



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	20		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A=25°C	P_D	300	400	mW
Derate above 25°C		1.7	2.3	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)		BV_{CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	0.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)			—	—	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 3 mAdc, V_{CE} = 1 Vdc)		h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	600	900	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	—	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	—	—	2.0	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 60 MHz, R_S = 400 ohms)		NF	—	3.0	6.0	dB
FUNCTIONAL TEST						
Amplifier Power Gain (I_C = 6 mAdc, V_{CB} = 12 Vdc, R_G = R_L = 50 ohms, f = 200 MHz)		G_{pe}	15	20	—	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio* (I_C = 4 mAdc, V_{CE} = 10 Vdc)	MD5000	h_{FE1}/h_{FE2}*	—	0.7	—	—
	MD5000A		0.9	—	1.0	
	MD5000B		0.8	—	1.0	
Base Voltage Differential (I_C = 4 mAdc, V_{CE} = 10 Vdc)	MD5000	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5.0	—	mVdc
	MD5000A		—	—	5.0	
	MD5000B		—	—	10	
Base Voltage Differential Change (I_C = 4 mAdc, V_{CE} = 10 Vdc, T_A = -55 to +125°C)	MD5000	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	—	μV/°C
	MD5000A		—	—	10	
	MD5000B		—	—	20	

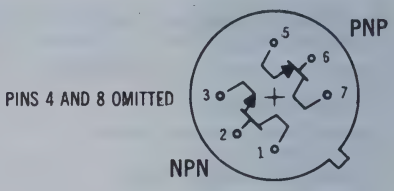
*The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD6001, F (SILICON)
MD6002, F



CASE 654-04

Silicon annular complementary-pair dual transistor is designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.



PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
DC Collector Current (Limited by P_D)	I_C	300		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D	500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.2	2.0	W
Derate above 25°C		6.83	11.43	mW/°C

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse diodes, voltage polarities, and input pulses.

FIGURE 1 — NPN TURN-ON TIME

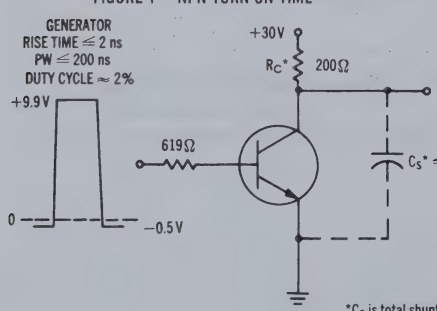
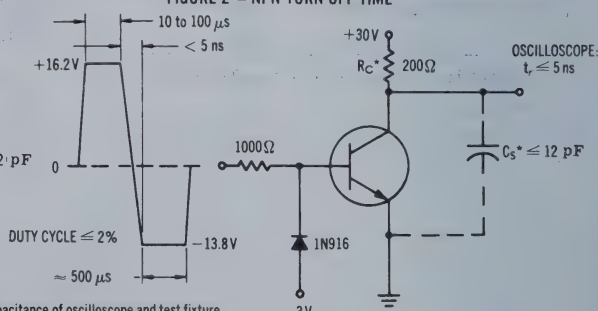


FIGURE 2 — NPN TURN-OFF TIME



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

MD6001, F, MD6002, F (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)			BV_{CEO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)			I_{CEX}	—	0.02	μAdc
(V_{CE} = 50 Vdc, V_{EB} = 3 Vdc, T_A = 150°C)				—	30	
Base Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)			I_{BL}	—	0.03	μAdc
ON CHARACTERISTICS						
DC Current Gain [1]			h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD6001, MD6001F			20	—	
	MD6002, MD6002F			35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD6001, MD6001F			25	—	
	MD6002, MD6002F			50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD6001, MD6001F			35	—	
	MD6002, MD6002F			75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001, MD6001F			40	120	
	MD6002, MD6002F			100	300	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	MD6001, MD6001F			20	—	
	MD6002, MD6002F			50	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD6001, MD6001F			20	—	
	MD6002, MD6002F			30	—	
Base-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)			$V_{BE(sat)}$	—	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)				—	2.0	
Collector-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)			$V_{CE(sat)}$	—	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)				—	1.4	
DYNAMIC CHARACTERISTICS						
Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)			f_T	—	200	MHz
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{ob}	—	8.0	pF
Collector Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)			C_{ib}	—	30	pF
Delay Time	See Figure 1	V_{CC} = 30 V, $V_{BE(off)}$ = 0.5 V	t_d	---	20	ns
Rise Time		I_C = 150 mA, I_{B1} = 15 mA	t_r	---	40	ns
Storage Time	See Figure 2	V_{CC} = 30 V, I_C = 150 mA	t_s	---	280	ns
Fall Time		I_{B1} = I_{B2} = 15 mA	t_f	—	70	ns

[1] Pulse Test: PW ≤ 300 μ , Duty Cycle ≤ 2%

MD6003 (SILICON)
MD6003F

SILICON ANNULAR COMPLEMENTARY DUAL TRANSISTORS

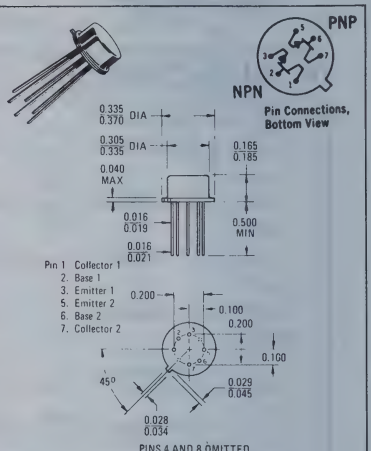
. . . designed for DC to VHF amplifier applications and complementary circuitry.

- Contains One NPN and One PNP Transistor Having Identical Specifications
- NPN Transistor Similar to the 2N2218 or 2N2219 PNP Transistor Similar to the 2N2904 or 2N2905
- DC Current Gain Specified – 0.1 mAdc to 300 mAdc
- High Current Gain – Bandwidth Product – f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc

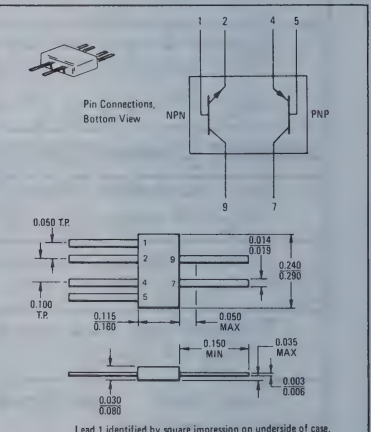
MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	300		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Can Package		500	600	mW
Derate above 25°C		2.87	3.43	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
Can Package		1.2	2.0	Watts
Derate above 25°C		6.86	11.43	mW/°C

NPN-PNP COMPLEMENTARY DUAL SILICON TRANSISTORS



MD6003
Case 654-04
(Formerly Case 32-02)



Case 610A

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

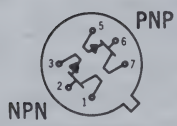
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	–	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	pF
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	30	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MD6100 (SILICON)

Dual NPN-PNP complementary-pair silicon annular transistor designed for complementary circuits where low-level, low-noise amplification is required.





PINS 4 AND 8 OMITTED

Pin Connections, Bottom View

CASE 654-04

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current-Continuous	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.83	2.0 11.43	Watts mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 10	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 500 μAdc, V_{CE} = 5 Vdc) (I_C = 1 mAdc, V_{CE} = 5 Vdc) (I_C = 10 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50 100 150 150 125	— — — — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	— —	0.7 0.8	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	—	0.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5 Vdc, f = 30 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3k ohms, Noise Bandwidth = 10 Hz to 15 kHz)	NF	—	4.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

MD7000 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTOR

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 150 mAdc
- DC Current Gain Specified –
  1.0 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product –
  f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTOR



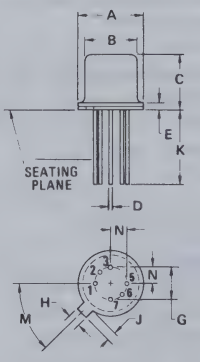
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C	P_D	575	625	mW
Derate above 25°C		3.29	3.57	mW/°C
Total Power Dissipation @ T_C = 25°C	P_D	1.8	2.5	Watts
Derate above 25°C		10.3	14.3	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	60	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	80	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	50	–	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.2	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.95	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	15	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

MD7001 (SILICON)
MD7001F
MQ7001

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified — 1.0 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product — f_T = 320 MHz (Typ) @ I_C = 20 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATING

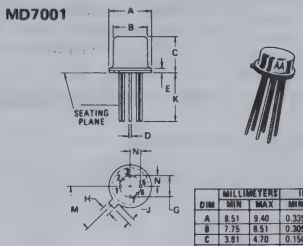
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD7001		600	650	
MD7001F		350	400	
MQ7001		400	600	
Derate above 25°C				mW/°C
MD7001		3.42	3.7	
MD7001F		2.0	2.28	
MQ7001		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD7001		2.1	3.8	
MD7001F		1.25	2.5	
MQ7001		1.0	4.0	
Derate above 25°C				mW/°C
MD7001		12	17.2	
MD7001F		7.15	14.3	
MQ7001		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7001		292	270	
MD7001F		500	438	
MQ7001		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7001		83.3	58.3	
MD7001F		140	70	
MQ7001		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD7001		85	40	
MD7001F		75	0	
MQ7001 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7001

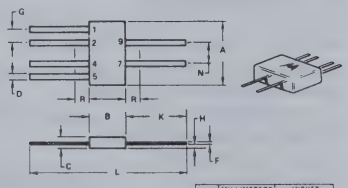


STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7001F

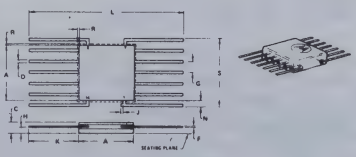


STYLE 1
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
L	10.54		0.415	
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7001



STYLE 1
PIN
Q1 { 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
Q2 { 5. EMITTER
6. BASE
7. COLLECTOR
Q3 { 8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
Q4 { 12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J		0.38		0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$.

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 300 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 40 70 30	 50 90 60	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.25	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.88	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	16	30	pF

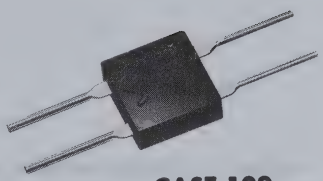
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

SILICON
MINIATURE DIODE ASSEMBLIES

MDA920 series



CASE 108
MDA920



CASE 109
MDA920A

Miniature Integral Diode Assemblies (MIDA)are low-current rectifier circuit configurations designed with a high output-current/size ratio for applications where space is at a premium. MIDA packages are available with flat ribbon leads and with round leads. For round leads, add suffix "A" to type number. Example, MDA920A-1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell (I_F = 500 mA Continuous)	V_F	1.2	Vdc
Maximum Reverse Current (Figure 2) (V_R = Rated V_{RM}) 25°C 100°C	I_R	60 600	μAdc

MECHANICAL CHARACTERISTICS

CASE: Transfer molded plastic encapsulation.

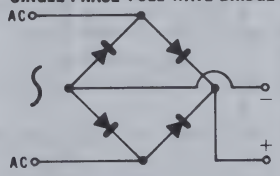
FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Embossed symbol on 4-lead devices.
Terminal designation by color dots on 3-lead devices:
AC input — yellow
+DC output — red
—DC output — white

MOUNTING POSITION: Any.

WEIGHT (approx.): 0.4 gram.

SINGLE PHASE FULL WAVE BRIDGE



ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

MOTOROLA TYPE NO.	DEVICE MARKING LETTER SYMBOLS	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) V_{RM} Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) V_{in} Volts	DC OUTPUT VOLTAGE Res. Load V_{out} Volts	DC OUTPUT VOLTAGE Cap. Load V_{out} Volts	DC OUTPUT CURRENT @ 75°C AMBIENT I_{out} Amp	PEAK FULL WAVE ONE CYCLE SURGE CURRENT NON-REPETITIVE (SINUSOIDAL 60 cps) $I_{FM(surge)}$ Amp	PEAK FULL WAVE REPETITIVE FORWARD CURRENT (NONSINUSOIDAL 60 cps) $I_{FM(rep)}$ Amp
MDA920-1	BA	25	18	15	25			
-2	BB	50	35	30	50			
-3	BC	100	70	62	100			
-4	BD	200	140	124	200	1.0	32.0	5.0
-5	BE	300	210	185	300			
-6	BF	400	280	250	400			
-7	BG	600	420	380	600			

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

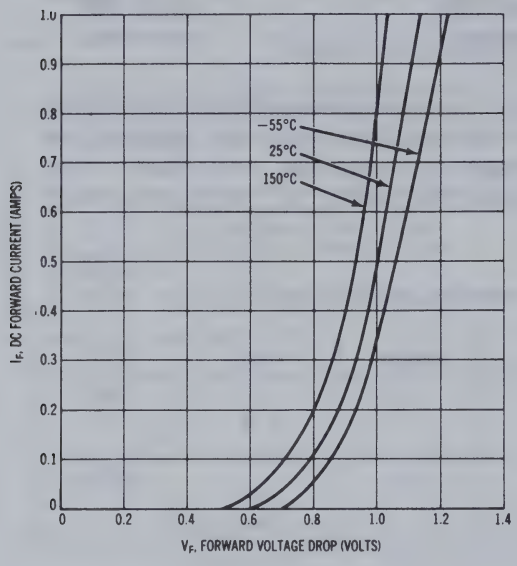


FIGURE 2 — TYPICAL REVERSE CHARACTERISTICS

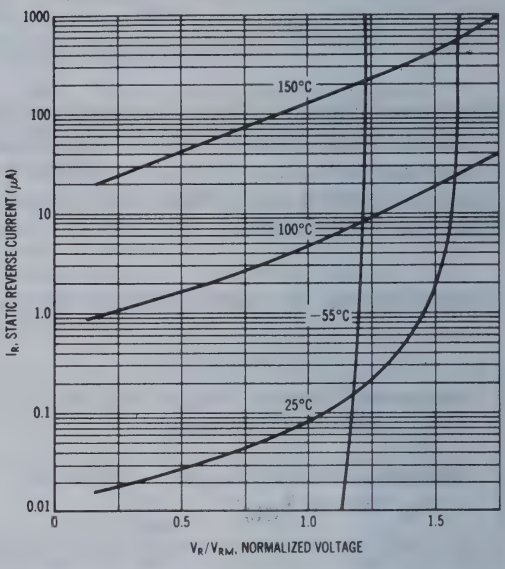


FIGURE 3 — MAX ALLOWABLE SURGE CURRENT

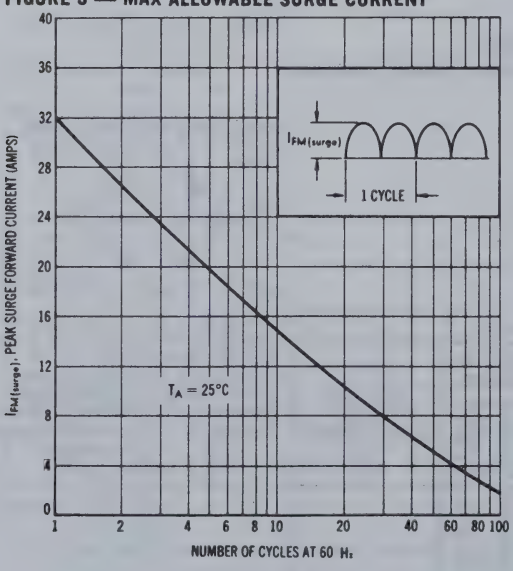
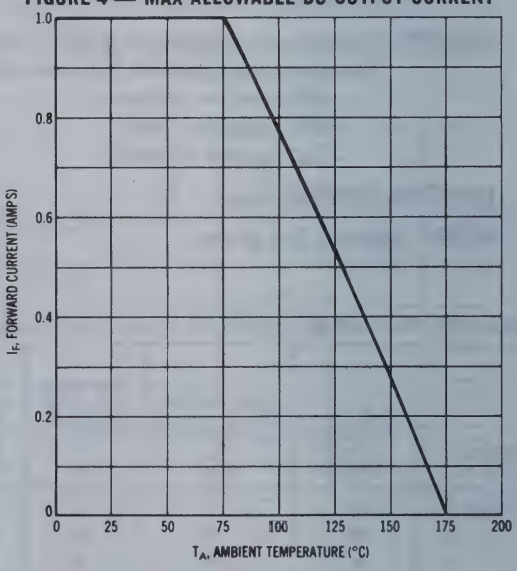


FIGURE 4 — MAX ALLOWABLE DC OUTPUT CURRENT



MDA922-1 (SILICON)
thru
MDA922-9

Designers Data Sheet

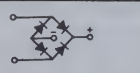
MINIATURE INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused-silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies.

- Large Inrush Surge Capability — 100 A (For 1.0 Cycle)
- Efficient Thermal Management Provides Maximum Power Handling in Minimum Space

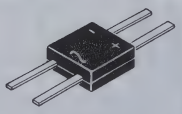
Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.



SINGLE-PHASE
FULL-WAVE BRIDGE

1.8 AMPERES
25 — 1000 VOLTS



MAXIMUM RATINGS

Rating (Per Leg)	Symbol	-1	-2	-3	-4	-5	-6	-7	-8	-9	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	25	50	100	200	300	400	600	800	1000	Volts
DC Output Voltage Resistive Load Capacitative Load	 Vdc Vdc	 15 25	 30 50	 62 100	 124 200	 185 300	 250 400	 380 600	 500 800	 620 1000	 Volts Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	18	35	70	140	210	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge resistive load, 60 Hz, see Figure 6, $T_A = 55^oC$)	I_O	1.8									Amp
Non-Repetitive Peak Surge Current, (see Figure 2) rated load, $T_J = 175^oC$ no load, $T_J = 25^oC$	I_{FSM}	60 (for 1 cycle) 100 (for 1 cycle)									Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +175									^oC

ELECTRICAL CHARACTERISTICS

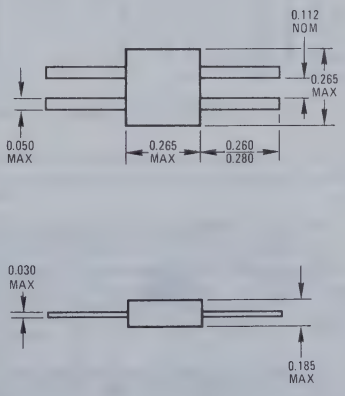
Characteristic	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (Per Leg) ($I_F = 0.75$ Amp, $T_J = 25^oC$) Figure 1	V_F	1.1	Volts
Maximum Reverse Current (Rated dc Voltage across ac terminals, $T_J = 25^oC$)	I_R	20	μA

THERMAL CHARACTERISTICS)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Full-Wave Bridge Operation, Typical Printed Circuit Board Mounting)	$R_{\theta JA}$	40	$^oC/W$

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation.
POLARITY: Terminal-designation embossed on case +DC output
-DC output
~AC input
MOUNTING POSITION: Any
WEIGHT: 1.0 gram (approx)
TERMINALS: Readily solderable connections, corrosion resistant.



CASE 216-01

FIGURE 1 – FORWARD VOLTAGE (PER LEG)

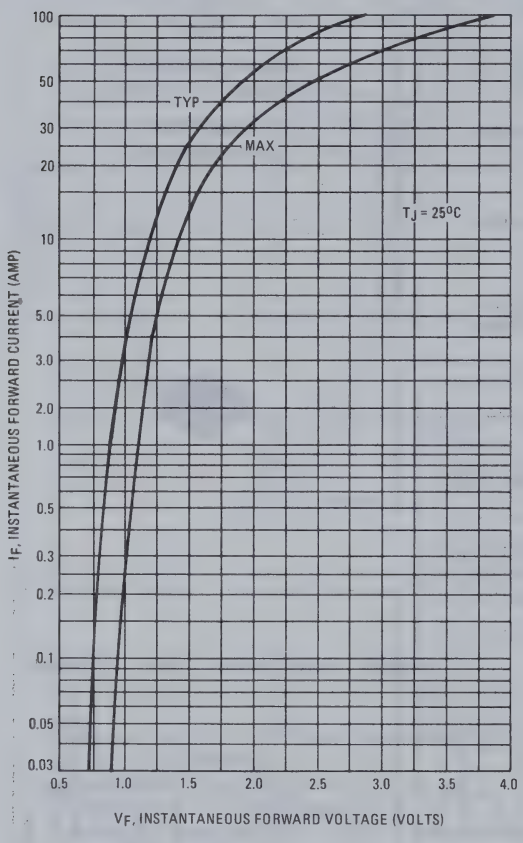


FIGURE 2 – MAXIMUM SURGE CAPABILITY

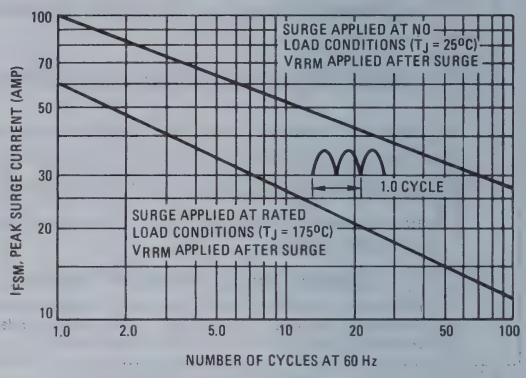


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

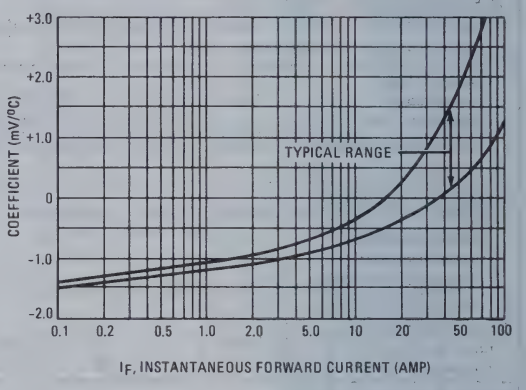


FIGURE 4 – TYPICAL THERMAL RESPONSE

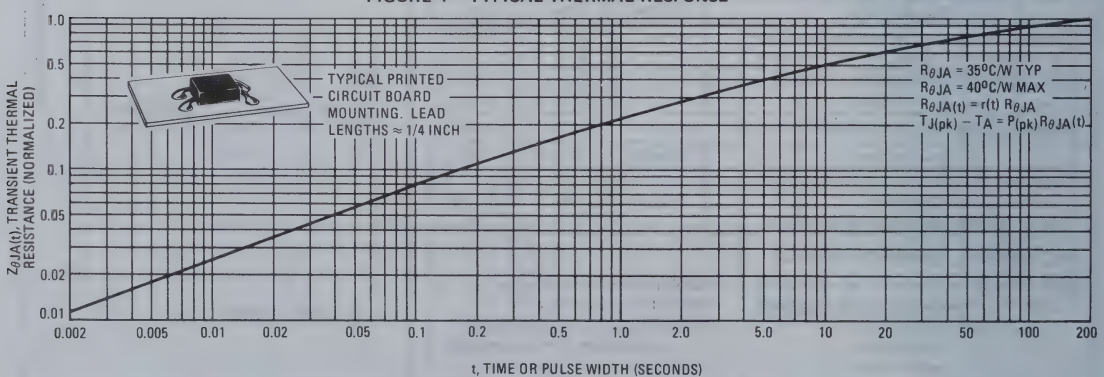


FIGURE 5 – POWER DISSIPATION

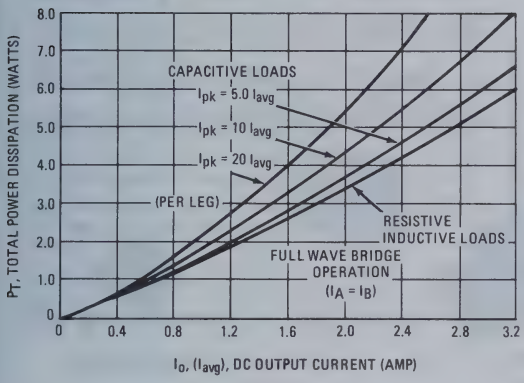


FIGURE 6 – CURRENT DERATING

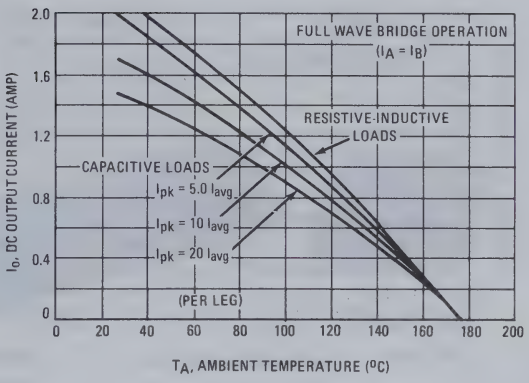
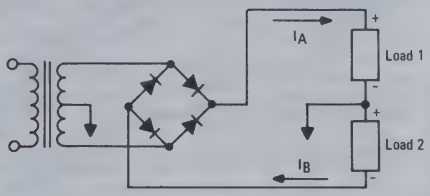


FIGURE 7 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



CIRCUIT A



CIRCUIT B

APPLICATION NOTE

The Data of Figure 4 applies for typical wire terminal or printed circuit board mounting conditions in still air. Under these or similar conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

Bridge rectifiers are used in two basic circuit configurations as shown by circuits A and B of Figure 7. The current derating data of Figure 6 applies to the standard bridge circuit (A), where $I_A = I_B$. The derating data considers the thermal response of the junction and is based upon the criteria that the junction temperature must not exceed rated $T_{J(max)}$ when peak reverse voltage is applied. However, because of the slow thermal response and the close thermal coupling between the individual semiconductor die in the MDA922 assembly, the maximum ambient temperature is given closely by

$$T_A = T_{J(max)} - R_{\theta JA} P_T$$

where P_T is the total average power dissipation in the assembly.

For the circuit of Figure B, use of the above formula will yield suitable rating information. For example to determine $T_{A(max)}$ for the conditions:

I_A = 2.0A, I_{PK} = 8.0 I_{avg}
I_B = 1.0A, I_{PK} = 18 I_{avg}

From Figure 5: For I_A, read $P_{TA} \approx 4.2W$
For I_B, read $P_{TB} \approx 2.2W$

$P_T = (P_{TA} + P_{TB}) \div 2 = 3.2W$

(Division by 2 is necessary as data from Figure 5 is for full wave bridge operation.) $\therefore T_{A(max)} = 175^o - (40)(3.2) = 47^oC$.

TYPICAL DYNAMIC CHARACTERISTICS (PER LEG)

FIGURE 8 – FORWARD RECOVERY TIME

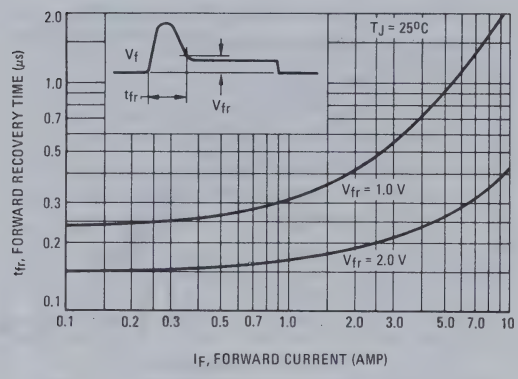


FIGURE 9 – REVERSE RECOVERY TIME

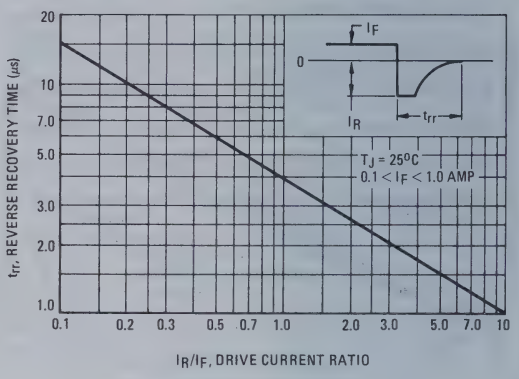


FIGURE 10 – RECTIFICATION WAVEFORM EFFICIENCY

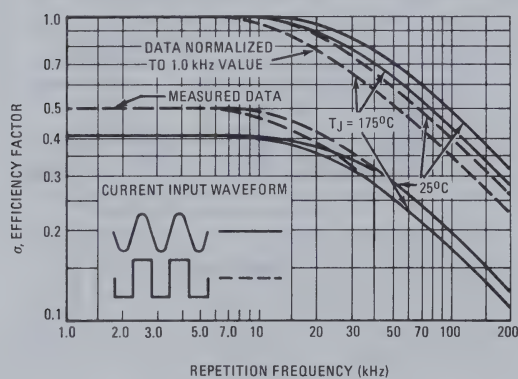
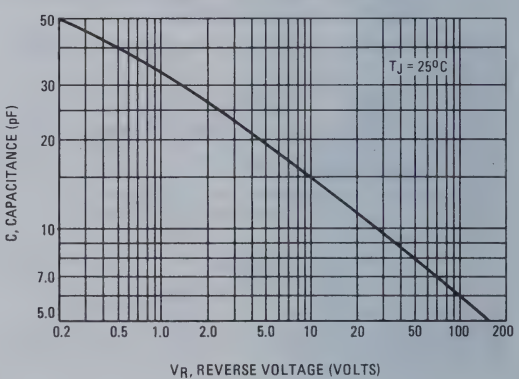
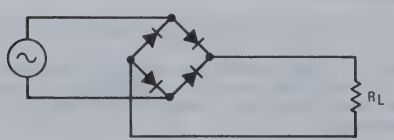


FIGURE 11 – CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 12 – SINGLE-PHASE FULL-WAVE BRIDGE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\frac{V^2_{o(dc)}}{R_L}}{\frac{V^2_{o(rms)}}{R_L}} \cdot 100\% = \frac{V^2_{o(dc)}}{V^2_{o(ac)} + V^2_{o(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{4V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{2R_L}} \cdot 100\% = \frac{8}{\pi^2} \cdot 100\% = 81.2\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2_m}{R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 100\% \quad (3)$$

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 10.

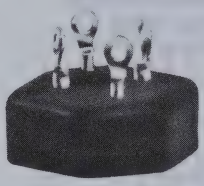
It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

SILICON
MOLDED ASSEMBLY RECTIFIER BRIDGES

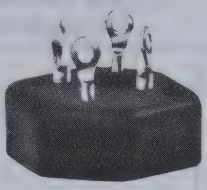
Single-Phase Full-Wave Bridge

MDA942 SERIES (1.5 AMPS DC)
MDA952 SERIES (6.0 AMPS DC)
MDA962 SERIES (10.0 AMPS DC)
MDA972 SERIES (16.0 AMPS DC)
MDA1491 SERIES (1.5 AMPS DC)
MDA1591 SERIES (4.0 AMPS DC)

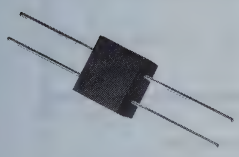
Three-Phase Full-Wave Bridge
MDA1505 SERIES (8.0 AMPS DC)



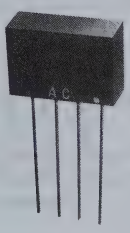
MDA952
CASE 113



MDA962
CASE 115



MDA942
CASE 110



MDA942A
CASE 111



MDA972
CASE 116



MDA1505
CASE 114



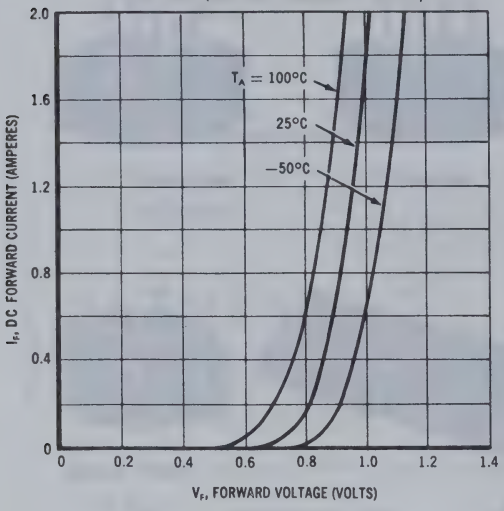
MDA1491
MDA1591
CASE 112

Molded assembly rectifier bridges are individual hermetically sealed rectifiers interconnected and encapsulated in molded assemblies for use as single-phase and three-phase full-wave bridge configurations, with output current from 1.5 to 16 amps, peak reverse voltage from 50 to 600 volts.

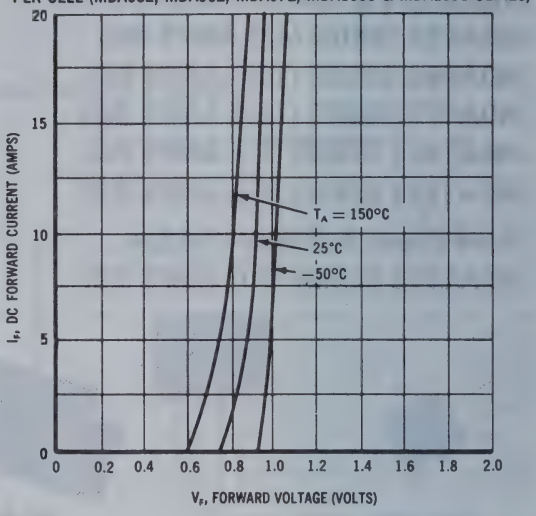
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell		V_F		Vdc
(I_F = 0.75 Adc)	MDA942 series		1.1	
(I_F = 3.0 Adc)	MDA952 series		1.0	
(I_F = 5.0 Adc)	MDA962 series		1.0	
(I_F = 5.0 Adc)	MDA972 series		1.0	
(I_F = 0.75 Adc)	MDA1491 series		1.1	
(I_F = 4.0 Adc)	MDA1505 series		1.0	
(I_F = 2.0 Adc)	MDA1591 series		1.0	
Maximum Reverse Current per Cell		I_R		mAdc
(V_R = Rated V_{RM})	MDA942 series		0.01	
	MDA952 series		1.0	
	MDA962 series		1.0	
	MDA972 series		1.0	
	MDA1491 series		0.01	
	MDA1505 series		1.0	
	MDA1591 series		1.0	

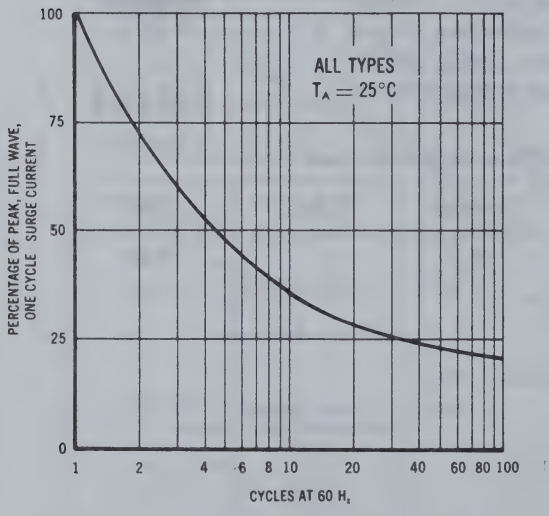
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA942 & MDA1491 SERIES)



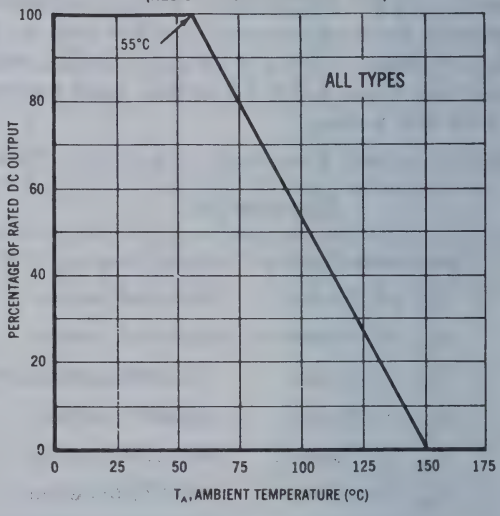
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA952, MDA962, MDA972, MDA1505 & MDA1591 SERIES)



MAXIMUM ALLOWABLE FULL WAVE SURGE CURRENT AT RATED LOAD CONDITIONS



MAXIMUM ALLOWABLE DC OUTPUT
(RESISTIVE OR INDUCTIVE LOAD)



MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation.

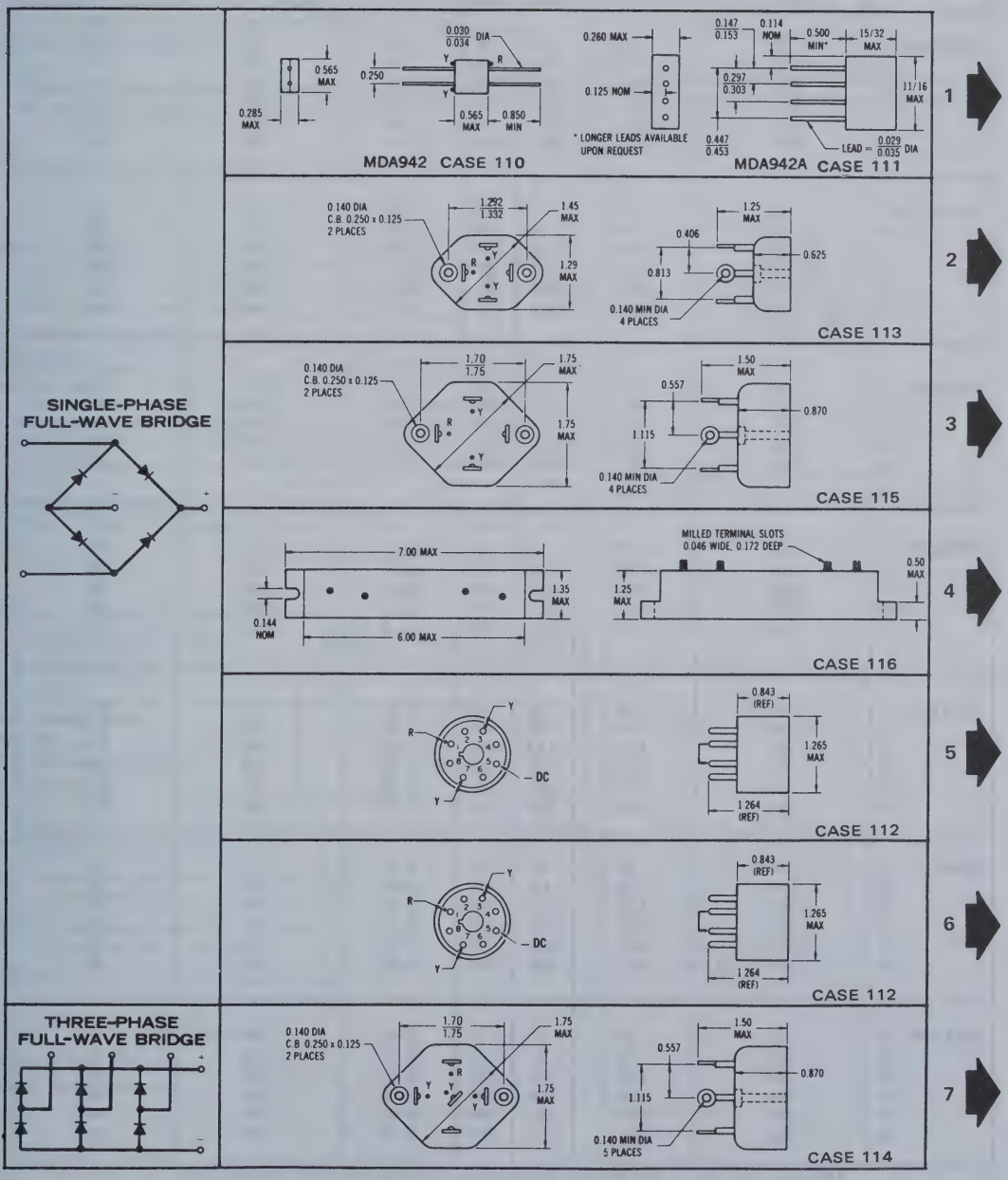
FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal designation by color dots:
AC input — yellow
+DC output — red
−DC output — not marked

MOUNTING POSITION: Any

WEIGHT (approx.):
MDA942, MDA942A — 3.8 grams
MDA952 — 35 grams
MDA962, MDA1505 — 92 grams
MDA972 — 340 grams
MDA1491 — 33 grams
MDA1591 — 39 grams

RECTIFIER BRIDGES (continued)



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

	TYPE NO.	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) Volts	DC OUTPUT VOLTAGE		DC OUTPUT CURRENT @ 55°C AMBIENT Amps	PEAK FULL WAVE ONE CYCLE SURGE CURRENT (60 Hz) Amps	PEAK FULL WAVE RECURRENT FORWARD CURRENT (60 Hz) Amps
				Res. Load Volts	Cap. Load Volts			
1	MDA942-1	50	35	30	50	1.50	25	6.0
	-2	100	70	62	100	1.50	25	6.0
	-3	200	140	124	200	1.50	25	6.0
	-4	300	210	185	300	1.50	25	6.0
	-5	400	280	250	400	1.50	25	6.0
	-6	600	420	380	600	1.50	25	6.0
2	MDA952-1	50	35	30	50	6.00	150	35
	-2	100	70	62	100	6.00	150	35
	-3	200	140	124	200	6.00	150	35
	-4	300	210	185	300	6.00	150	35
	-5	400	280	250	400	6.00	150	35
	-6	600	420	380	600	6.00	150	35
3	MDA962-1	50	35	30	50	10.0	250	60
	-2	100	70	62	100	10.0	250	60
	-3	200	140	124	200	10.0	250	60
	-4	300	210	185	300	10.0	250	60
	-5	400	280	250	400	10.0	250	60
4	MDA972-1	50	35	30	50	16.0	250	60
	-2	100	70	62	100	16.0	250	60
	-3	200	140	124	200	16.0	250	60
	-4	300	210	185	300	16.0	250	60
	-5	400	280	250	400	16.0	250	60
5	MDA1491-1	50	35	30	50	1.50	25	6.0
	-2	100	70	62	100	1.50	25	6.0
	-3	200	140	124	200	1.50	25	6.0
	-4	300	210	185	300	1.50	25	6.0
	-5	400	280	250	400	1.50	25	6.0
	-6	600	420	380	600	1.50	25	6.0
6	MDA1591 -1	50	35	30	50	4.00	100	25
	-2	100	70	62	100	4.00	100	25
	-3	200	140	124	200	4.00	100	25
	-4	300	210	185	300	4.00	100	25
	-5	400	280	250	400	4.00	100	25
	-6	600	420	380	600	4.00	100	25
7	MDA1505 -1	50	35	47	50	8.00	200	45
	-2	100	70	95	100	8.00	200	45
	-3	200	140	190	200	8.00	200	45
	-4	300	210	285	300	8.00	200	45
	-5	400	280	380	400	8.00	200	45
	-6	600	420	570	600	8.00	200	45

Maximum Operating and Storage Temperature: -65°C to +150°C (All Types)

MDA952FR-1
thru
MDA952FR-5

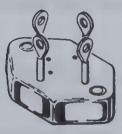
MOLDED ASSEMBLY RECTIFIER BRIDGE

. . . individual hermetically sealed fast recovery rectifiers interconnected and encapsulated in molded assemblies for use as single-phase full-wave bridge, with output current of 6 Amps, and peak reverse voltage from 50 to 400 volts.

- Maximum Recovery Time of 0.2 Microsecond Provides High Efficiency at Frequencies of 125 kHz or Higher

SINGLE-PHASE FULL-WAVE BRIDGE

6 AMPERES
50 thru 400 VOLTS

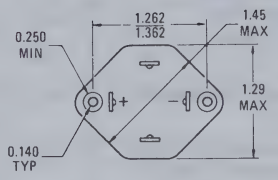


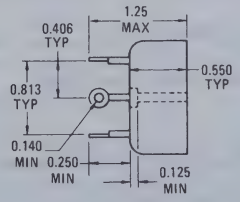
MAXIMUM RATINGS

		MDA952FR					
Rating (Per Leg)	Symbol	-1	-2	-3	-4	-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$	50	100	200	300	400	Volts
DC Blocking Voltage	V_R	50	100	200	300	400	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 31 50	 62 100	 124 200	 185 300	 250 400	Volts
RMS Input Voltage	V_r	35	70	140	212	282	Volts
DC Output Current @ T_A = +55°C	I_O	← 6.0 →					Amp
Peak Full-Wave, One-Cycle Surge Current (60 Hz)	$I_{FM(surge)}$	← 150 →					Amp

ELECTRICAL CHARACTERISTICS PER LEG (T_C = 25°C)

Characteristic and Conditions	Symbol	Max	Unit
Maximum Forward Voltage Drop (I_F = 3.0 Amp)	V_F	1.1	Vdc
Maximum Reverse Current (Rated V_R)	I_R	50	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp)	t_{rr}	200	ns





Case 113

MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation, hermetically sealed individual rectifier cells.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal-designation embossed on case
+DC output
−DC output
AC not marked

MOUNTING POSITION: Any

WEIGHT: 35 grams (approx.)

MDA970-1
thru
MDA970-3

Designers Data Sheet

INTEGRAL DIODE ASSEMBLIES

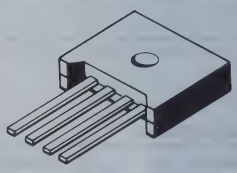
. . . diffused silicon dice interconnected and transfer molded into rectifier circuit assemblies for use in applications where high output current/size ratio is of prime importance. These devices feature:

- Void-free, Transfer-molded Encapsulation to Assure High Resistance to Shock, Vibration, and Temperature Extremes
- High Dielectric Strength
- Simple, Compact Structure for Trouble-free Performance
- High Surge Capability – 100 Amps



SINGLE-PHASE
FULL-WAVE BRIDGE

4 AMPERES
50 – 200 VOLTS



CASE 117

Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

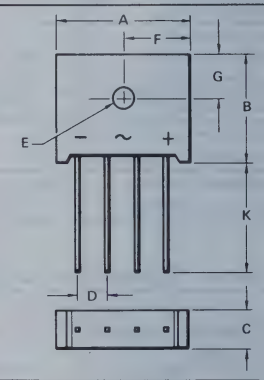
Rating	Symbol	MDA970-1	MDA970-2	MDA970-3	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 31 50	 62 100	 124 200	Volts
Average Rectified Forward Current T_A = 25°C T_C = 55°C	I_O	← 4.0 → ← 8.0 →			Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, T_J = 150°C)	I_{FSM}	← 100 →			Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← –65 to +150 →			°C

THERMAL CHARACTERISTICS

Characteristics		Symbol	Max (Per Die)	Unit
Thermal Resistance, Junction to Case	Each Die	$R_{\theta JC}$	10	°C/W
	Effective Bridge	$R_{\theta(EFF)}$	7.75	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Instantaneous Forward Voltage (Per Diode) (i_F = 6.28 Amp, T_J = 25°C) (i_F = 6.28 Amp, T_J = 150°C)	v_F	– – –	 0.9 0.8	Vdc
Reverse Current (Rated V_{RM} applied to ac terminals, + and – terminals open, T_A = 25°C)	I_R	–	1.0	mA



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.880	0.920	22.350	23.370
B	0.715	0.755	18.160	19.180
C	0.240	0.280	6.100	7.110
D	0.180	0.220	4.570	5.590
E	0.135	0.155	3.430	3.940
F	0.440	0.460	11.180	11.680
G	0.285	0.305	7.240	7.750
K	0.750	–	19.050	–

Leads must fit into 0.055" (1.40 mm) Hole

CASE: Transfer-molded plastic encapsulation.
FINISH: All external surfaces are corrosion-resistant. Leads are readily solderable.
POLARITY: Embossed symbols
AC input = ~
DC output = +
DC output = –
MOUNTING POSITION: Any
WEIGHT (Approximately): 7.5 Grams
MOUNTING TORQUE: 5 in.-lb Max

FIGURE 1 – FORWARD VOLTAGE

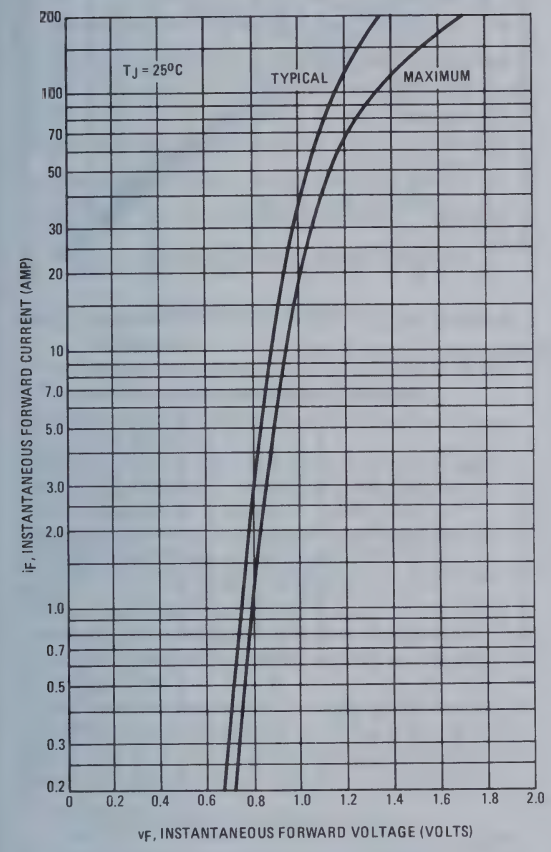


FIGURE 2 – MAXIMUM SURGE CAPABILITY

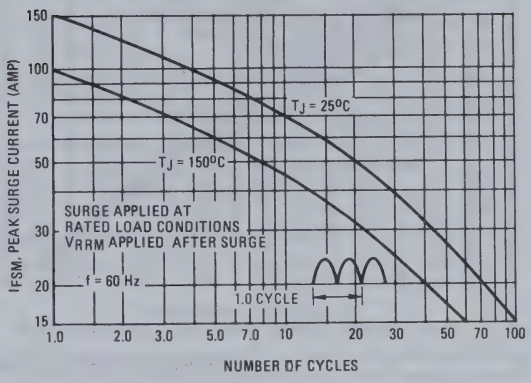


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

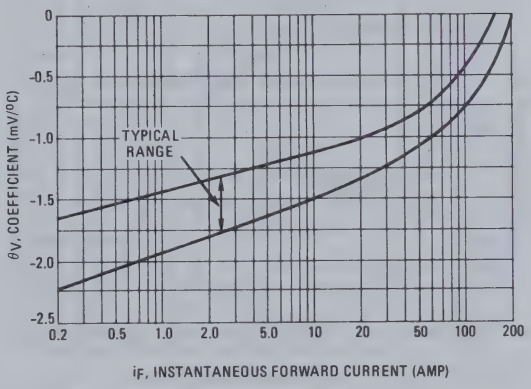
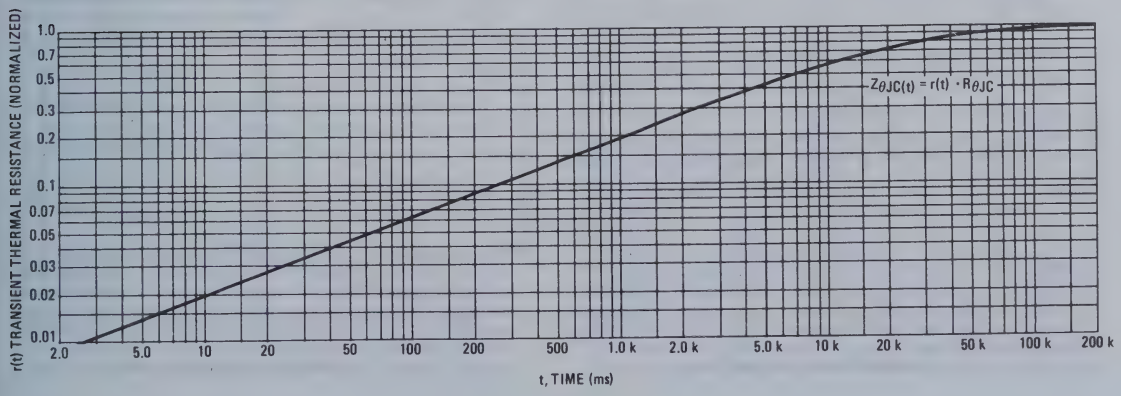


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – CASE TEMPERATURE DERATING

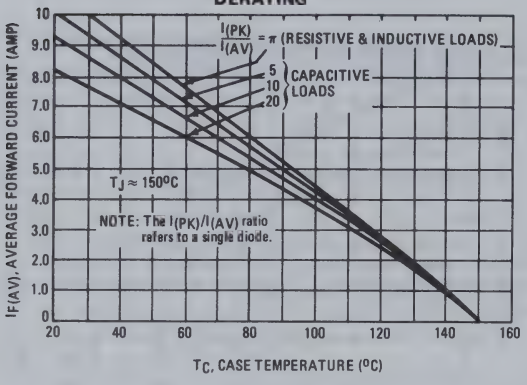
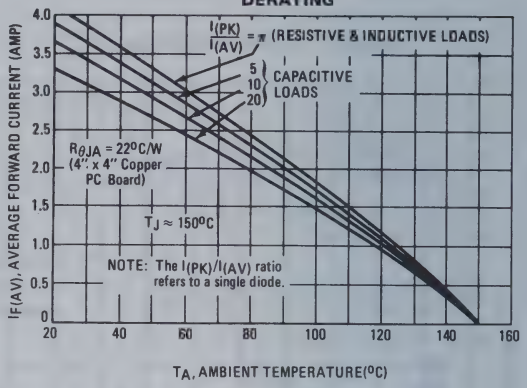


FIGURE 6 – AMBIENT TEMPERATURE DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION EFFICIENCY

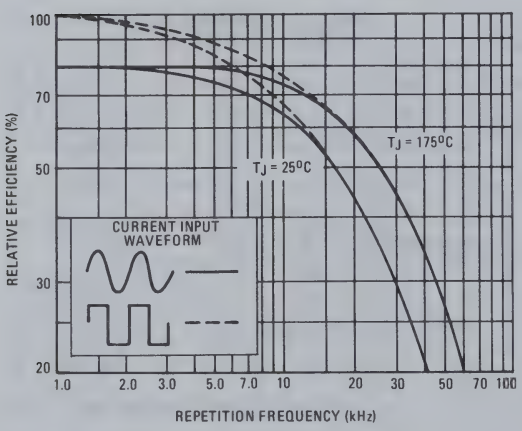


FIGURE 8 – REVERSE RECOVERY TIME

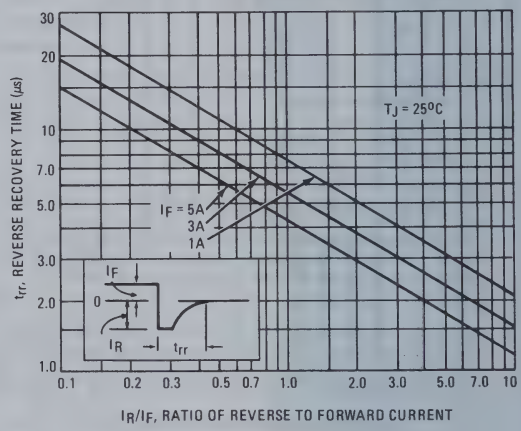


FIGURE 9 – JUNCTION CAPACITANCE

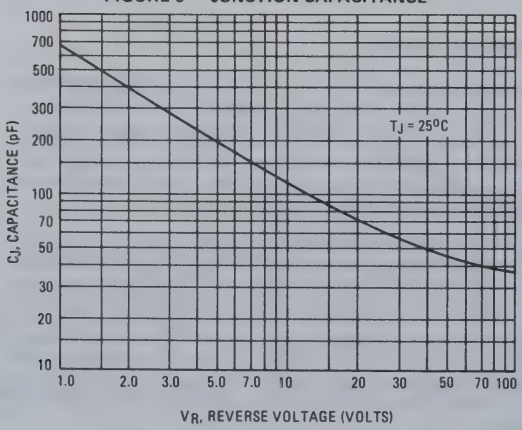


FIGURE 10 – FORWARD RECOVERY TIME

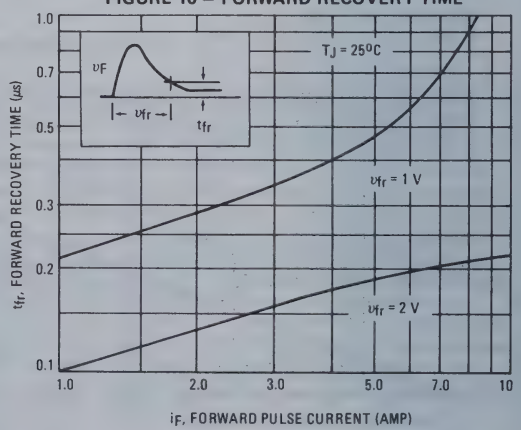


FIGURE 11 – POWER DISSIPATION

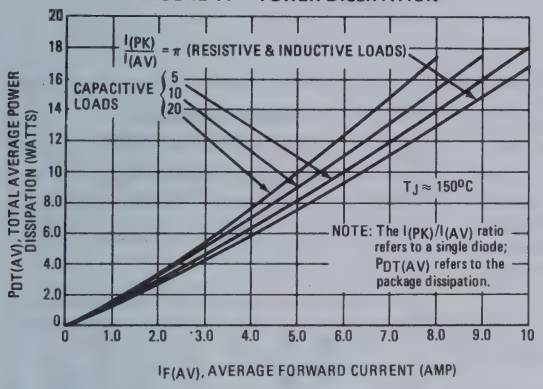
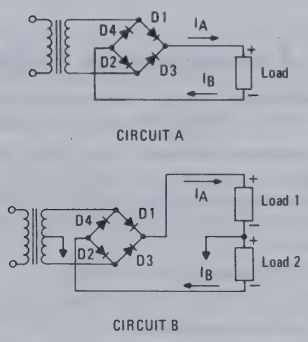


FIGURE 12 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



NOTE 1: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of diode 1

$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of diodes 1 through 4

$P_{D1 \text{ thru } 4}$ is the power dissipated in diodes 1 through 4

$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For this rectifier assembly, thermal coupling between opposite diodes is 65% and between adjacent diodes is 72.5% when the case temperature is used as a reference. When the ambient temperature is used as the reference, the coupling is a function of the mounting conditions and is essentially the same for opposite and adjacent diodes.

The effective bridge thermal resistance, junction to ambient, is (from equation 4).

(5) $R_{\theta(EFF)JA} = R_{\theta JA}(1 + 3K_{\theta(AV)JA})/4$

Where: $K_{\theta(AV)JA} \approx (K_{\theta(AV)JC} R_{\theta JC} + R_{\theta CA})/R_{\theta JA}$ and $K_{\theta(AV)JC}$ is approximately 70%. $R_{\theta CA}$ is the case to ambient thermal resistance.

NOTE 2: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 12. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(6) $T_{R(MAX)} = T_{J(MAX)} - \triangle T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

$\triangle T_{J1}$ can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the following load conditions:

I_A = 3.1 A average with a peak of 11.2 A

I_B = 1.55 A average with a peak of 6.8 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 11.2/1.55 = 7.23 (Note that the peak to average ratio is on a per diode basis.)

From Figure 11, for an average current of 3.1 A and an $I_{(PK)}/I_{(AV)}$ = 7.23 read $P_{T(AV)}$ = 4.8 watts or 1.2 watts/diode $\therefore$ $P_{D1} = P_{D3}$ = 1.2 watts.

Similarly, for a load current I_B of 1.55 A, diode #2 and diode #4 each see 0.775 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 8.8$.

Thus, the package power dissipation for 1.55 A is 2.3 watts or 0.575 watts/diode $\therefore$ $P_{D2} = P_{D4}$ = 0.575 watts.

The maximum junction temperature occurs in diode #1 and #3. From equation (3) for diode #1 $\triangle T_{J1} = 9[1.2 + .65(.575) + .725 (1.2) + .725 (.575)]$

$\triangle T_{J1} \approx 26^oC$

Thus $T_{C(MAX)} = 150\text{-}26 = 124^oC$

The total package dissipation in this example is:

$P_J = 2 \times 1.2 + 2 \times 0.575 \approx 3.6$ watts

(Note that although maximum $R_{\theta JC}$ is 10^oC/watt, 9^oC/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value.)

NOTE 3

Under typical wire terminal or printed circuit board mounting conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

MDA980-1 thru MDA980-6
MDA990-1 thru MDA990-6

Designers Data Sheet

INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies. The MDA990 series incorporates an electrically insulated aluminum disc for improved heat dissipation when mounted directly on a metal chasis or heat sink.

- Large surge capability – 300 A
- Efficient Thermal Management Provides Maximum Power Handling In Minimum Space

Designers Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	-1	-2	-3	-4	-5	-6	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 30 50	 62 100	 124 200	 185 300	 250 400	 380 600	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, T_C = 55°C) MDA980 MDA990	I_O	12 30						Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	300						Amp
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +175						°C

THERMAL CHARACTERISTICS

Characteristic			Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	Each Die	MDA980	$R\theta_{JC}$	8.5	11	°C/W
		MDA990		4.5	6.0	
	Effective Bridge	MDA980	$R\theta_{(EFF)}$	–	6.05	°C/W
		MDA990		–	2.28	

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode)		V_F				Volts
(i_F = 18.9 A)	MDA980		–	0.88	0.97	
(i_F = 47 A)	MDA990		–	0.98	1.07	
(i_F = 18.9 A, T_J = 175°C)	MDA980		–	–	0.85	
(i_F = 47 A, T_J = 175°C)	MDA990		–	–	0.98	
Reverse Current (Rated V_{RM} applied to ac terminals, + and - terminals open)		I_R	–	–	0.5	mA

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Bolt down-highest heat transfer efficiency accomplished through the surface opposite the terminals.

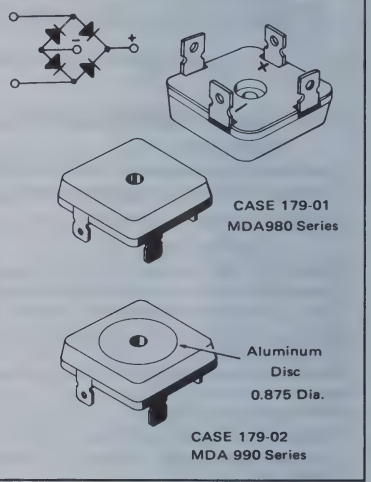
WEIGHT: MDA980 – 21 grams (approx.)
MDA990 – 22.5 grams (approx.)

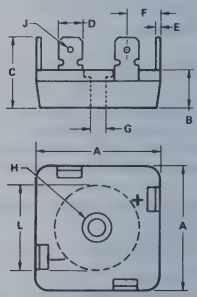
TERMINALS: Suitable for fast-on connections, readily solderable connections, corrosion resistant.

MOUNTING TORQUE: 20 in. lb. Max.

SINGLE-PHASE FULL-WAVE BRIDGE

12 and 30 AMPERES
50 thru 600 VOLTS





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.235	1.255	31.370	31.880
B	0.365	0.385	9.270	9.780
C	0.680	0.760	16.760	19.300
D	0.245	0.255	6.220	6.480
E	0.029	0.034	0.737	0.864
F	0.340	0.400	8.640	10.160
G	0.140	0.155	3.560	3.940
H	0.060	0.110	1.520	2.790
J	0.085	0.100	2.160	2.540
L	0.859	0.930	21.820	23.620

NOTES:
1. HOLE IS COUNTER SUNK FOR #6 SOCKET-HEAD SCREW
2. DIM "H" IS DEPTH MEASUREMENT, NOT DIAMETER.
3. DIM "C", "D", "E" & "J" ARE TYPICAL.
4. DIM "L" APPLIES TO-02 ONLY

CASE 179-01-02

FIGURE 1 – FORWARD VOLTAGE

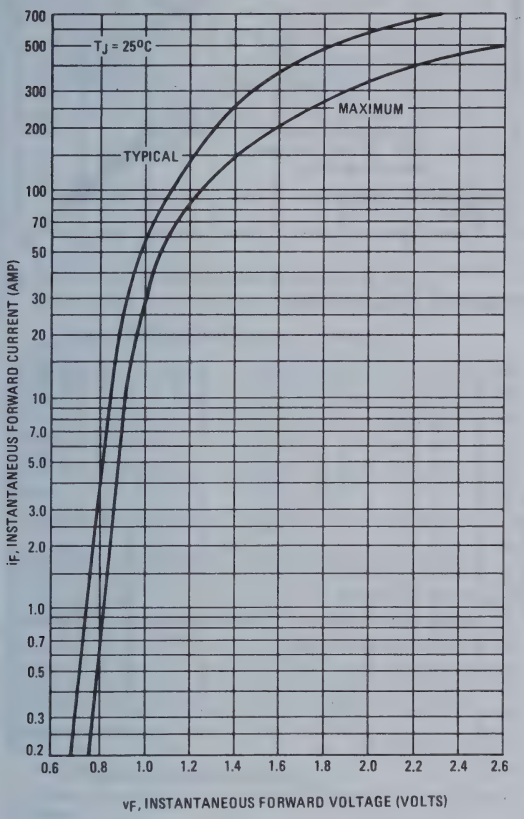


FIGURE 2 – MAXIMUM SURGE CAPABILITY

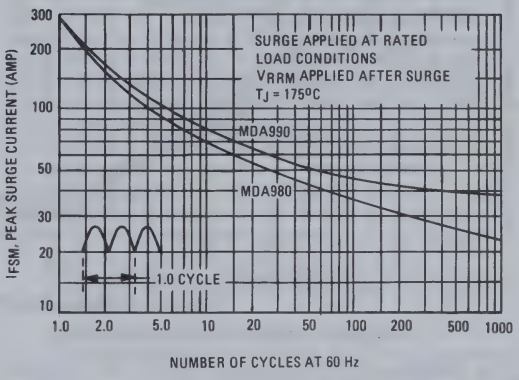


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

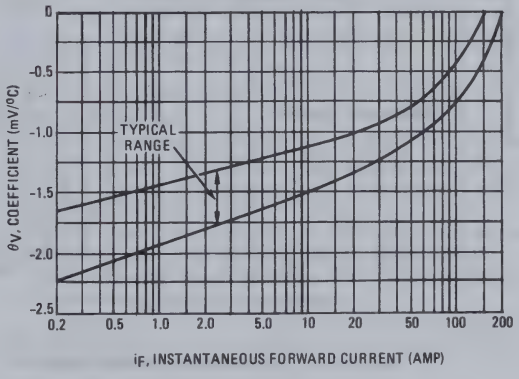
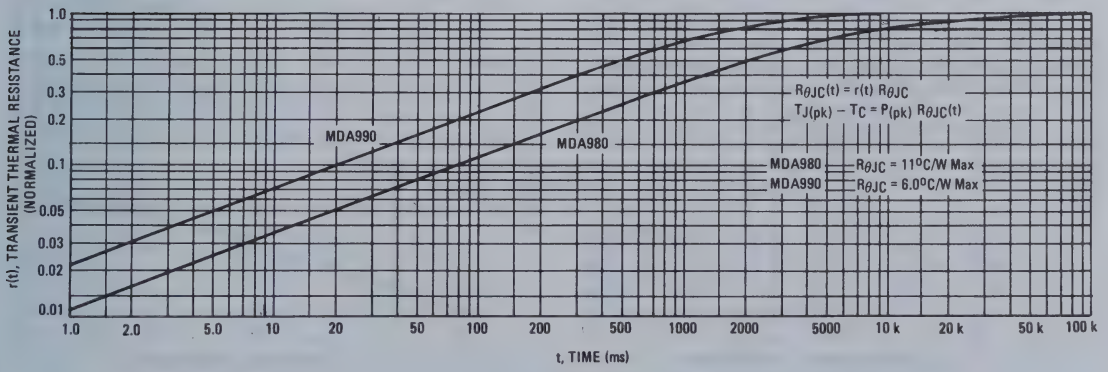


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – MDA980 CURRENT DERATING

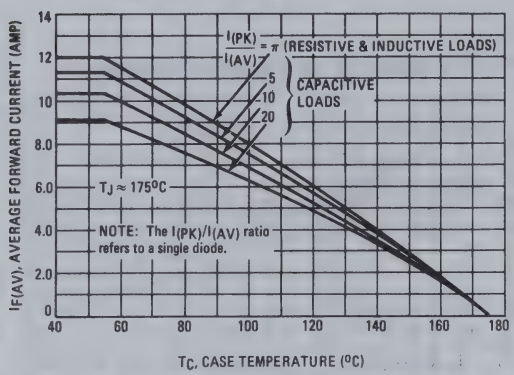
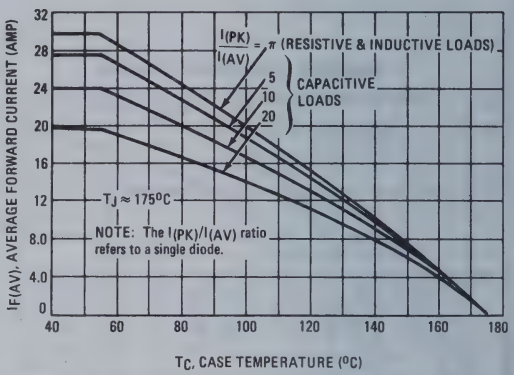


FIGURE 6 – MDA990 CURRENT DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION EFFICIENCY

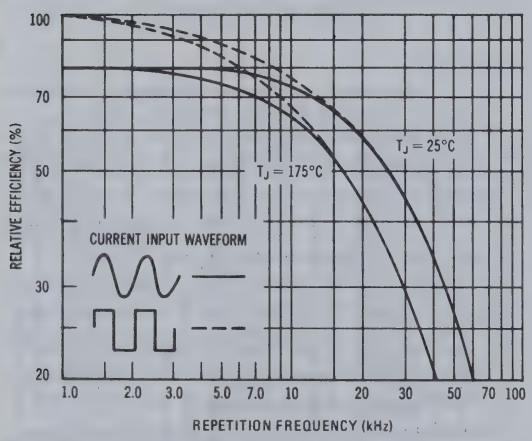


FIGURE 8 – JUNCTION CAPACITANCE

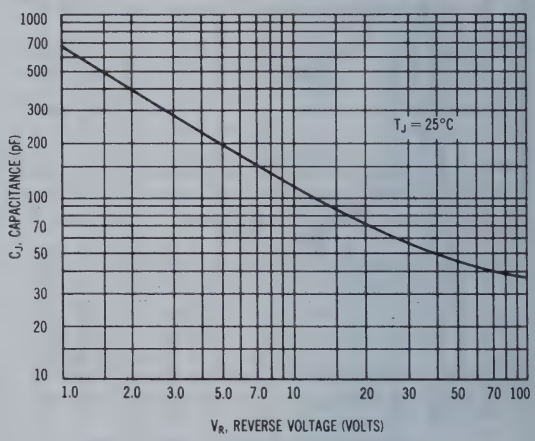


FIGURE 9 – REVERSE RECOVERY TIME

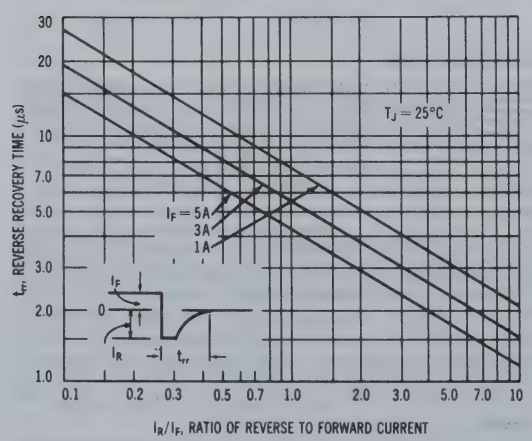


FIGURE 10 – FORWARD RECOVERY TIME

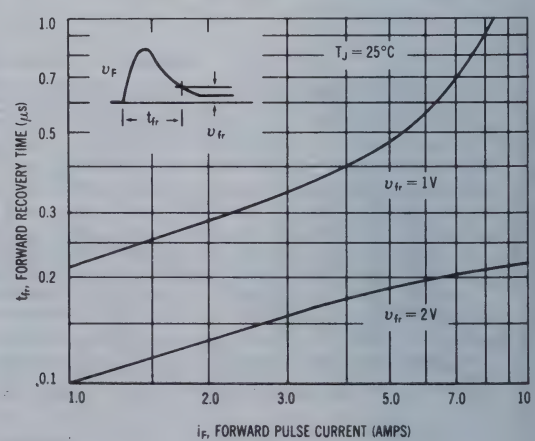


FIGURE 11 – POWER DISSIPATION

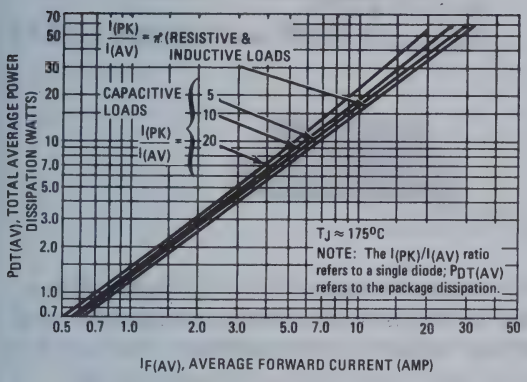
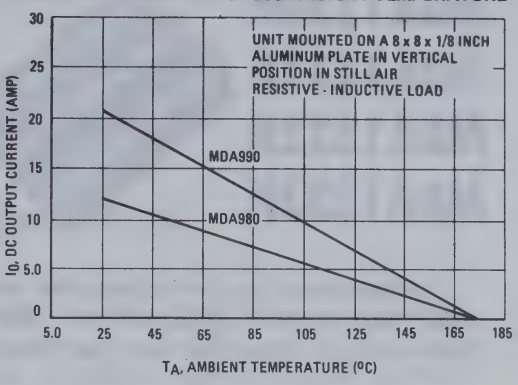


FIGURE 12 – CURRENT VERSUS AMBIENT TEMPERATURE



NOTE 1 – THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D2} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of diodes 1 through 4.

$P_{D1 \text{ thru } 4}$ is the power dissipated in diodes 1 through 4

$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condition where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_{D1}$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}\ (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For the MDA980 rectifier assembly, thermal coupling between opposite diodes is 42% and between adjacent diodes is 50% when the case temperature is used as a reference. Similarly for the MDA990, thermal coupling between opposite diodes is 12% and between adjacent diodes is 20%.

NOTE 2 – SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown in circuits A and B of Figure 13. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(5) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the MDA990 with the following capacitive load conditions:

I_A = 20 A average with a peak of 86 A
I_B = 10 A average with a peak of 72 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)} = 86/10 = 8.6$. (Note that the peak to average ratio is on a per diode basis and each diode provides 10A average).

From Figure 11, for an average current of 20 A and an $I_{(PK)}/I_{(AV)} = 8.6$ read $P_{DT(AV)} = 40$ watts or 10 watts/diode. Thus $P_{D1} = P_{D3} = 10$ watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 14.4$

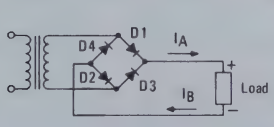
Thus, the package power dissipation for 10 A is 20.2 watts or 5.05 watts/diode. $\therefore P_{D2} = P_{D4} = 5.05$ watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1 $\Delta T_{J1} = 5.6\ [10 + 0.12\ (5.05) + 0.2\ (10) + 0.2\ (5.05)]$.

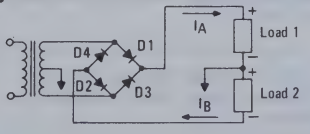
$\Delta T_{J1} \approx 76^oC$
Thus $T_{C(MAX)} = 175\text{-}76 = 99^oC$
The total package dissipation in this example is:
$P_J = 2 \times 10 + 2 \times 5.05 \approx 30.1$ watts

(Note that although maximum $R_{\theta JC}$ is $6^oC/W$, 5.6^oC/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value).

FIGURE 13 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



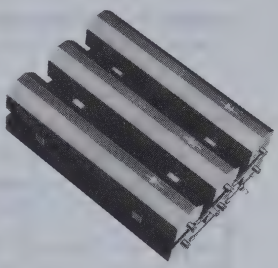
CIRCUIT A



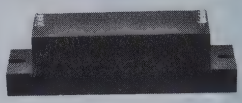
CIRCUIT B

HIGH VOLTAGE SILICON RECTIFIER MOLDED ASSEMBLIES

MDA1330H
MDA1331H
MDA1332H
MDA1333H



I_O — to 2.5 A
$V_{RM(rep)}$ = 5000 and 10,000 VOLTS



Compensated series-connected rectifier cells for high-voltage, single-phase, half-wave circuit applications. Each cell in the series string is shunted by a high-voltage capacitor and resistor for equal voltage distribution.

NOTES:

1. MDA1330H and MDA1331H, add suffix "C" for common cathode, "U" for common anode, "D" for voltage doubler.
2. MDA1332H and MDA1333H, reverse polarity available by adding suffix "R".

MAXIMUM RATINGS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Peak Repetitive Reverse Voltage ① (Rated Current, Over Operating Temperature Range)	$V_{RM(rep)}$	5,000	10,000	5,000	10,000	Volts
RMS Reverse Voltage (Rated Current Over the Complete Operating Temperature Range)	V_r	3,500	7,000	3,500	7,000	Volts
DC Blocking Voltage ② (Over Operating Temperature Range)	V_R	3,000	6,000	3,000	6,000	Volts
Average Half Wave Rectified Forward Current (Resistive Load, 180° Conduction Angle, 60cps, Free Convection Cooling) T_A = 40°C	I_O	1.0	1.0	2.5	2.5	Amps
T_A = 100°C		0.3	0.3	0.5	0.5	
Peak 1 Cycle Surge Current (T_A = 40°C, Superimposed on Rated Current at Rated Voltage)	$I_{FM(surge)}$	25	25	250	250	Amps
Operating Frequency Range	DC to 400					cps
Operating and Storage Temperature Range	-55 to +110					°C

① $V_{RM(rep)}$ ratings of 5,000 or 10,000 volts peak are both the maximum repetitive and non-repetitive ratings. Where voltage transient suppression is employed, these assemblies can be reliably operated at the maximum ratings.

② The DC Blocking Voltage rating (V_R), is established by the continuous power dissipation ratings of the shunting resistors and is not a function of the series rectifiers.

ELECTRICAL CHARACTERISTICS

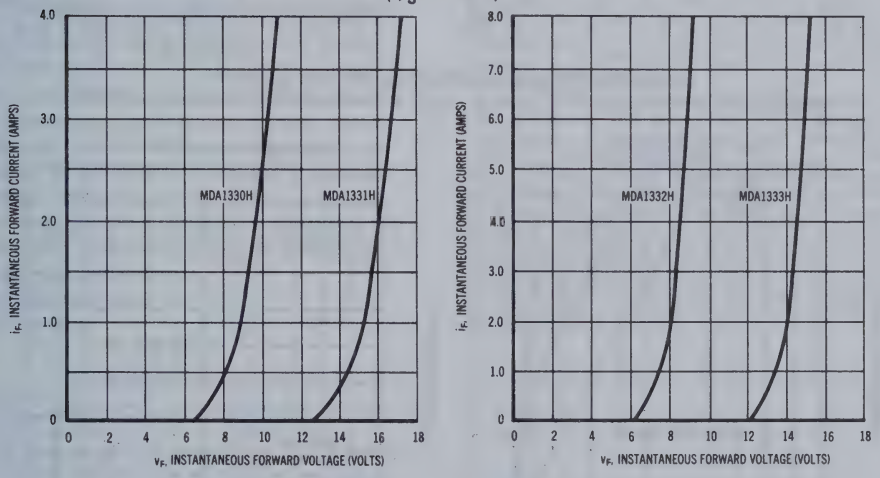
Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Maximum Full-Cycle Average Forward Voltage Drop (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$V_{F(AV)}$	5.0	10.0	5.0	10.0	Volts
Maximum Full-Cycle Average Reverse Current (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$I_{R(AV)}$	0.2	0.2	3.0	3.0	mA

Note: Ambient temperatures are measured at the cold air source point i.e. immediately below the rectifier legs under convection cooling and on the cool air side with forced air cooling.

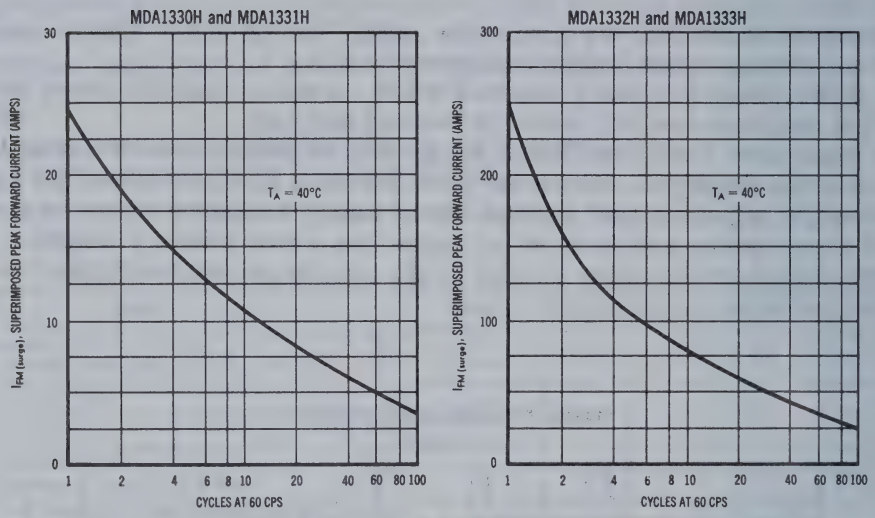
ELECTRICAL DESIGN NOTES

1. For single-phase, full-wave circuits using "Series 1300" stacks, multiply the current ratings given for the half-wave by two.
2. For three-phase, full-wave and half-wave circuits, multiply given current ratings for single-phase, half-wave by two and one half.
3. For capacitive loads, sufficient surge and capacitor inrush current protection must be employed. Recurrent peak currents up to six times the single-phase average output-current ratings can be safely sustained when the average value of these peaks are held at or below the rated average output. Non-repetitive peak currents must be held to the maximum surge ratings.

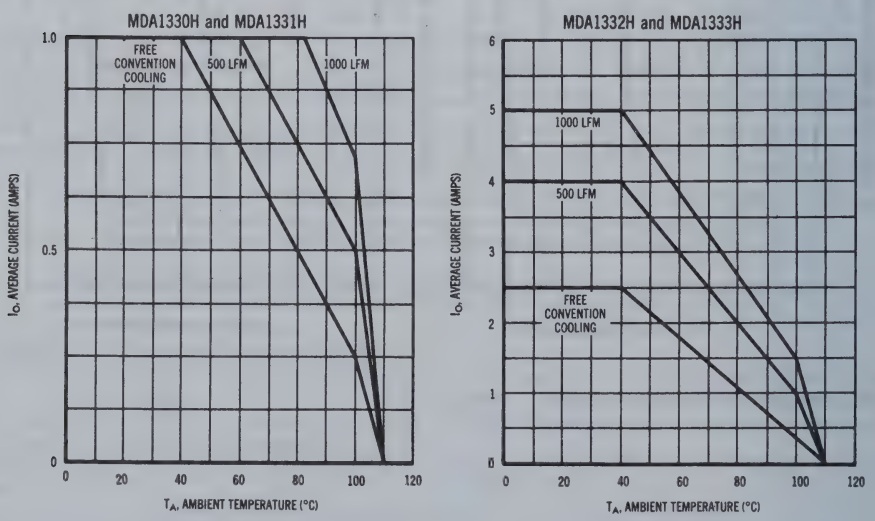
TYPICAL FORWARD CHARACTERISTICS
($T_J = 25^oC$)



MAXIMUM SURGE CURRENT
RATED CONDITIONS

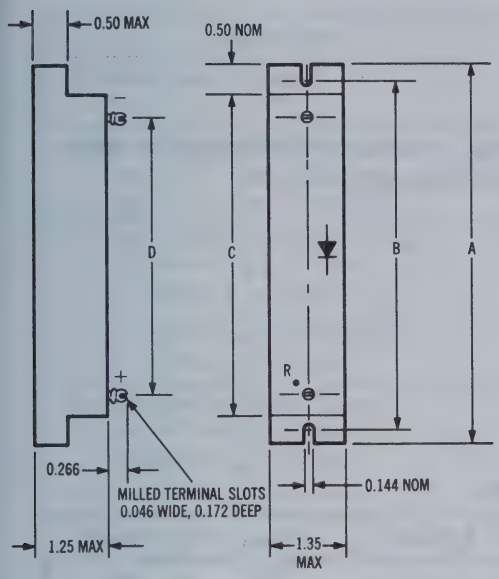


MAXIMUM AVERAGE HALF-WAVE RECTIFIED CURRENT
(RESISTIVE OR INDUCTIVE LOAD, 180° CONDUCTION ANGLE, 60 CPS)



HIGH VOLTAGE SILICON RECTIFIERS (continued)

MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1330H AND MDA1331H RECTIFIER LEGS.

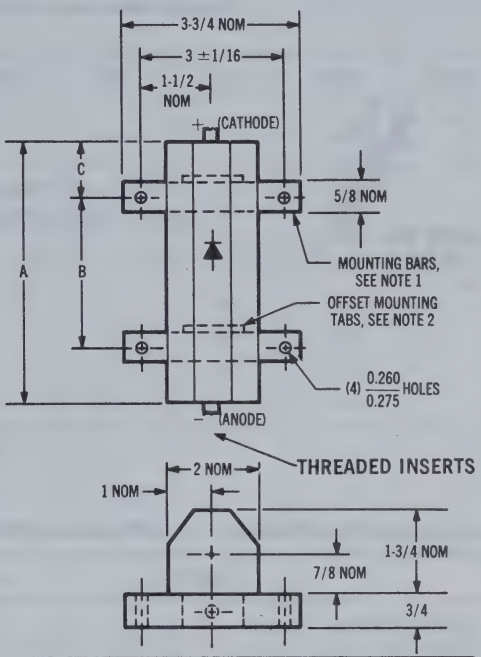


POLARITY DOTS: RED = +DC OUTPUT

Device	A Dim	B Dim	C Dim	D Dim
MDA1330H	4.25max	3.70±0.05	3.25max	3.00nom
MDA1331H	7.00max	6.39±0.05	6.00max	5.25nom

NOTES: These basic rectifier legs are suitable for chassis mounting and connection into multiple leg circuits. Center tapped versions of the MDA1330H and MDA1331H are also available for use in lower voltage, Center tapped and Voltage Doubler applications. The center tapped versions of the MDA1330H and MDA1331H are designated by a different suffix letter as follows: instead of "H" specify
"C" for common cathode, center tap
"U" for common anode, center tap
"D" for voltage doubler.

MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1332H AND MDA1333H RECTIFIER LEGS.

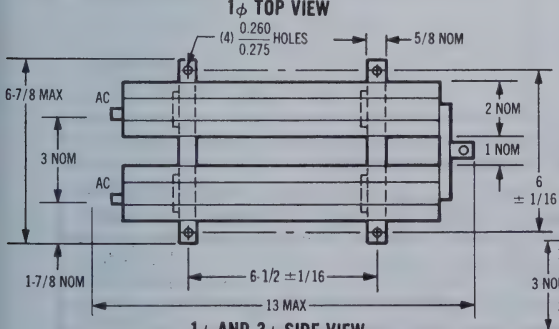


Device	A Dim	B Dim	C Dim
MDA1332H	5-5/8 nom	3-1/4 1/16	1-1/8 nom
MDA1333H	11-1/4 nom	6-1/2±1/16	2-3/8 nom

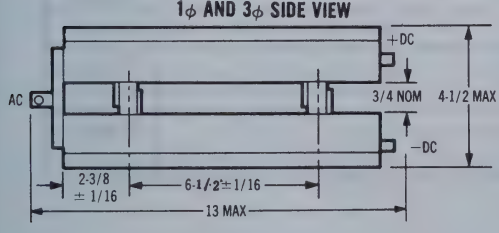
NOTE 1. Insulated mounting bars are supplied with all Series 1300 stacks and the single unit bar is shown above. For multiple leg circuits, mounting bars are available in lengths suitable for 2 or 3 legs mounted side by side. In addition, the mounting arrangement used is also suitable for mounting legs top and bottom on the same bar with stand-offs employed for support of the assembly.

NOTE 2. Offset mounting taps are used to provide more compact multiple leg assemblies. When top & bottom or side by side mounting is employed, reverse polarity legs are often required in some circuits. Legs of reverse polarity to that shown above are designated by an "R" suffix, i.e. MDA1332HR.

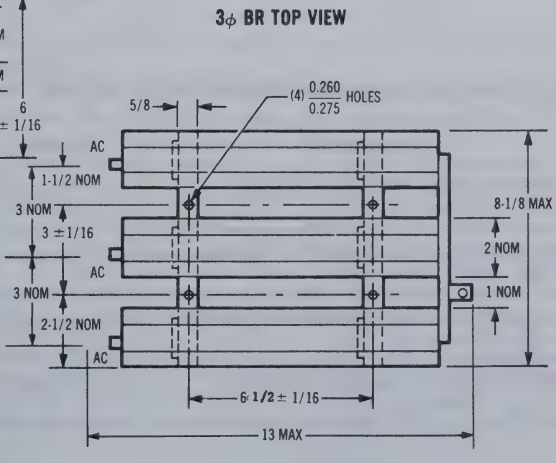
1φ TOP VIEW



1φ AND 3φ SIDE VIEW



3φ BR TOP VIEW



MF3304 (SILICON)



CASE 20
(TO-72)

PNP silicon epitaxial transistor designed for low-level, high-speed switching applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25° C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μA, I_B = 0)	BV_{CBO}	18	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μA, I_B = 0)	BV_{CES}	12	—	—	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$*	12	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 9 V, I_E = 0)	I_{CBO}	—	—	10	nA
Collector Reverse Current (V_{CE} = 6 V, V_{EB} = 0)	I_{CES}	—	—	10	nA
(V_{CE} = 6 V, V_{EB} = 0, 150°C)		—	—	10	μA
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	—	0.15	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		—	—	0.16	
(I_C = 10 mA, I_B = 1.0 mA, 125°C)		—	—	0.23	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	0.50	
Base-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{BE(sat)}$	0.7	—	0.8	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		0.8	—	0.9	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	1.2	
DC Current Gain (I_C = 1.0 mA, V_{CE} = -0.3 V)	h_{FE}	20	—	—	
(I_C = 10 mA, V_{CE} = -0.3 V)		30	—	120	
(I_C = 10 mA, V_{CE} = -0.3 V, -55°C)		15	—	—	
(I_C = 50 mA, V_{CE} = -1.0 V)		20	—	—	
High-Frequency Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 100 MHz)	h_{fe}	6.0	—	—	—
Output Capacitance** (V_{CB} = -5.0 V, I_E = 0, f = 140 kHz)	C_{ob}**	—	—	2.5	pF
Emitter Transition Capacitance (V_{EB} = -0.5 V, I_C = 0, f = 140 kHz)	C_{TE}	—	—	2.5	pF
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 10 mA, f = 31.8 MHz)	$r_b'C_c$	—	—	40	ps
Charge Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx$ -10 mA)	t_s	—	—	30	ns
Turn-On Time ($I_C \approx$ 10 mA, $I_{B1} \approx$ 0.5 mA)	t_{on}	—	—	60	ns
Turn-Off Time ($I_C \approx$ 10 mA, $I_{B1} \approx I_{B2} \approx$ -0.5 mA)	t_{off}	—	—	60	ns

TYPICAL AMPLIFIER PERFORMANCE

Noise Figure (V_{CE} = 10 V, I_C = 2 mA, f = 60 MHz, R_S = 200 ohms)	NF	—	2.7	—	dB
AC Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}	—	70	—	—
Current Gain — Bandwidth Product (V_{CE} = 10 V, I_C = 2 mA, f = 100 MHz)	f_T	—	700	—	MHz
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 2 mA)	$r_b'C_c$	—	15	—	ps

**Measured in guarded circuit
*Pulse Conditions: PW ≤ 300 μs, Duty Cycle ≤ 2%.

MFE2000 (SILICON)
MFE2001

Silicon N-channel junction field-effect transistor designed for VHF/UHF amplifier applications.

PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD



CASE 20(1)
(TO-72)

Active elements isolated from case

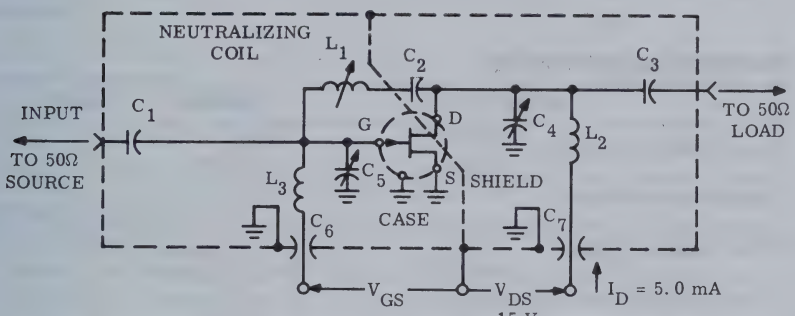
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	-	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	MFE2000 MFE2001	V_{GS}	0.5 3.0	- -	4.0 7.5	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)		I_{GSS}	-	-	100	pAdc
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	200	nAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE2000 MFE2001	I_{DSS}	4.0 8.0	- -	10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE2000 MFE2001	$\|y_{fs}\|$	2500 4000	- -	6000 8000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE2000 MFE2001	$\|y_{os}\|$	- -	- -	50 75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	-	5.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	-	-	2.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	-	1.0	pF
Small-Signal Power Gain (Figure 1) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)		G_{ps}	18	23	-	dB
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)			10	14	-	
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz, R_G ≈ 1.0 k ohm)		NF	-	1.6	2.0	dB
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz, R_G ≈ 1.0 k ohm)			-	3.3	4.0	

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED AMPLIFIER



NOTE:

The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C_1	7.0 pF	1.8 pF
C_2	1000 pF	27 pF
C_3	3.0 pF	1.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.25 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

* L_1 17 turns (approximately - depending on circuit layout), AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I. D.

L_3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I. D.

** L_1 6 turns approximately - (depending on circuit layout), AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L_2 1 turn, AWG #16 enameled copper wire, 3/8" I. D.

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I. D.

MFE2004 (SILICON)
MFE2005
MFE2006

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.



CASE 22(4)
(TO-18)

PIN 1. SOURCE
2. DRAIN
3. GATE AND SOURCE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0 (V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	- -	0.2 0.4	nAdc μAdc
Drain Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc) (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)		$I_{D(off)}$	- -	0.2 0.4	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current[1] (V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2004 MFE2005 MFE2006	I_{DSS}	8.0 15 30	- - -	mAdc
Gate-Source Voltage (V_{DS} = 20 Vdc, I_D = 50 μAdc)	MFE2004 MFE2005 MFE2006	V_{GS}	1.0 2.0 5.0	6.0 8.0 10	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage (I_D = 3.0 mAdc, V_{GS} = 0) (I_D = 6.0 mAdc, V_{GS} = 0) (I_D = 10 mAdc, V_{GS} = 0)	MFE2004 MFE2005 MFE2006	$V_{DS(on)}$	- - -	0.4 0.4 0.4	Vdc
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MFE2004 MFE2005 MFE2006	$r_{DS(on)}$	- - -	80 50 30	Ohms

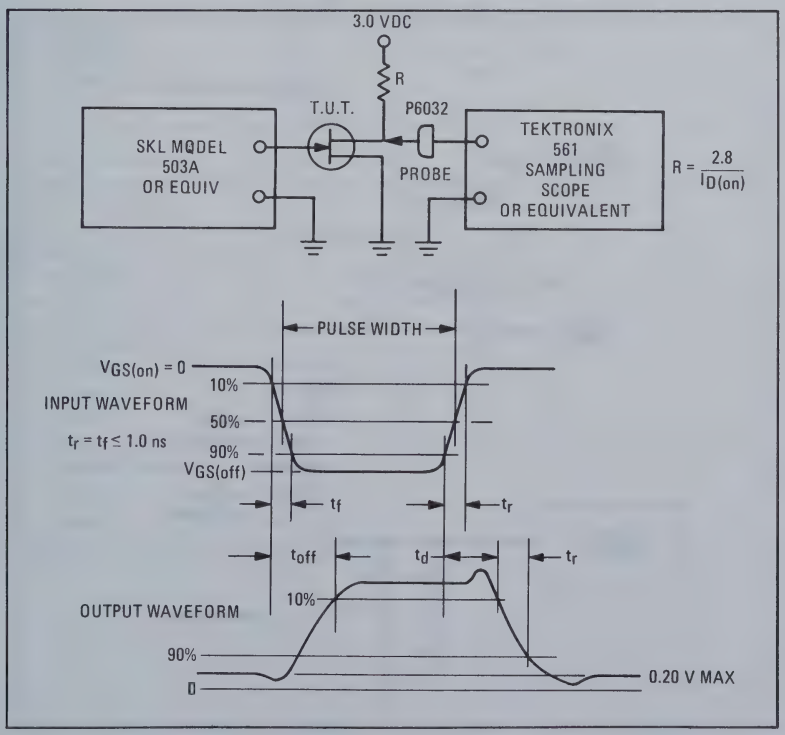
[1]Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE2004, MFE2005, MFE2006 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2004		-	80	
	MFE2005		-	50	
	MFE2006		-	30	
Input Capacitance		C_{iss}			pF
(V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)			-	16	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	MFE2004		-	5.0	
(V_{DS} = 0, V_{GS} = 8.0 Vdc, f = 1.0 MHz)	MFE2005		-	5.0	
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	MFE2006		-	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		-	20	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	15	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Rise Time (See Figure 1)		t_r			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		-	40	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	20	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Turn-Off Time (See Figure 1)		t_{off}			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, $V_{GS(off)}$ = 6.0 Vdc)	MFE2004		-	80	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, $V_{GS(off)}$ = 8.0 Vdc)	MFE2005		-	60	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MFE2006		-	40	

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MFE2007 (SILICON)
MFE2008
MFE2009

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.



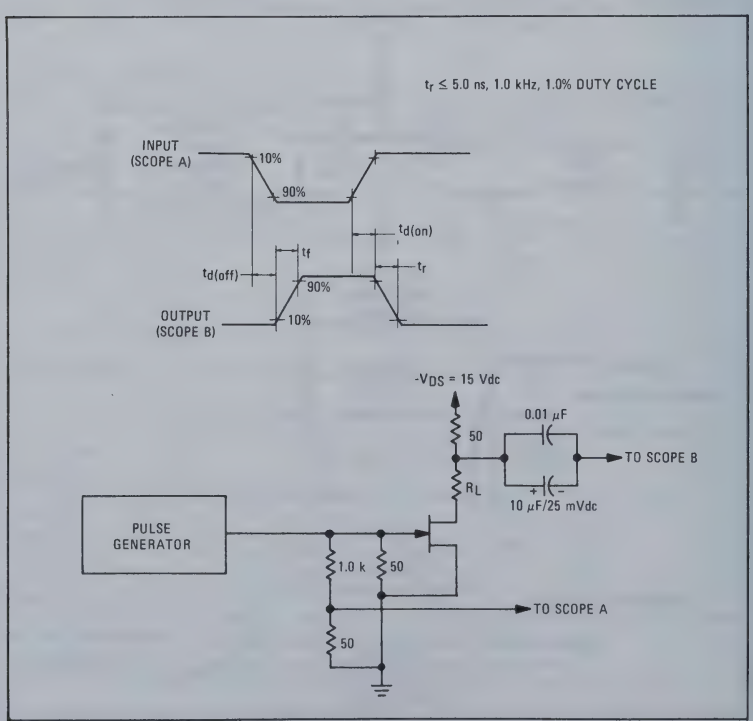
PIN 1. SOURCE
2. DRAIN
3. GATE AND CASE

CASE 22 (4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to + 175	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0)			-	2.0	
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	4.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			-	2.0	
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	4.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2007		8.0	-	
	MFE2008		20	-	
	MFE2009		50	-	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE2007		0.5	10	
	MFE2008		1.0	10	
	MFE2009		3.0	10	
Gate-Source Forward Voltage		VGSF			Vdc
(I_G = 1.0 mAdc, V_{DS} = 0)			-	1.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 5.0 mAdc, V_{GS} = 0)	MFE2007		-	0.75	
(I_D = 10 mAdc, V_{GS} = 0)	MFE2008		-	0.75	
(I_D = 20 mAdc, V_{GS} = 0)	MFE2009		-	0.75	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MFE2007		-	40	
	MFE2008		-	30	
	MFE2009		-	20	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2007		-	40	
	MFE2008		-	30	
	MFE2009			20	
Input Capacitance		C_{iss}			pF
(V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)			-	30	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)			-	15	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1)		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007		-	35	
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	20	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	12	
Fall Time (See Figure 1)		t_f			ns
(V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007		-	65	
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	40	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	25	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE2010 (SILICON)
MFE2011
MFE2012

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.



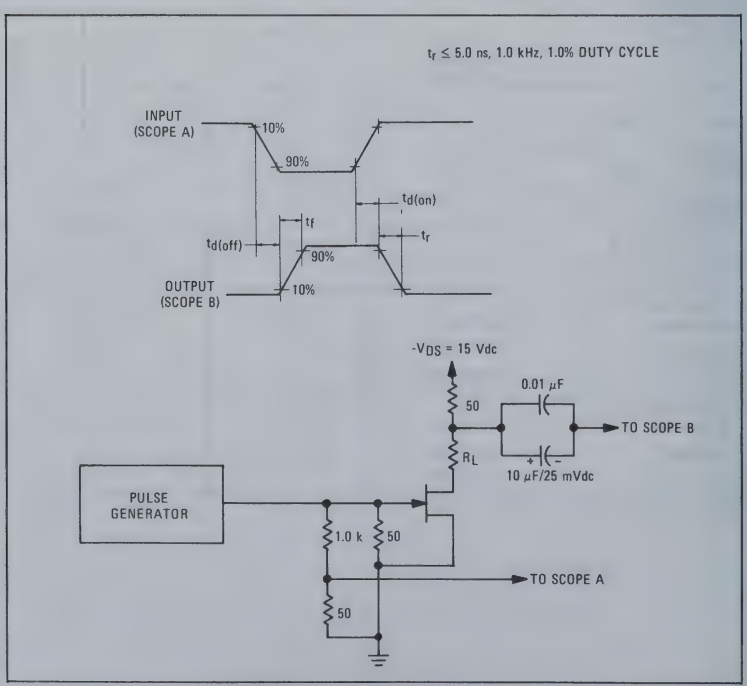
PIN 1. SOURCE
2. DRAIN
3. GATE AND CASE

CASE 22 (4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25° C	P_D	1.8 10	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0)			-	3.0	
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	6.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			-	3.0	
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	6.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1) (V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2010	I_{DSS}	15	-	mAdc
	MFE2011		40	-	
	MFE2012		100	-	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE2010	V_{GS}	0.5	10	Vdc
	MFE2011		1.0	10	
	MFE2012		3.0	10	
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 8.0 mAdc, V_{GS} = 0)	MFE2010		-	0.75	
(I_D = 15 mAdc, V_{GS} = 0)	MFE2011		-	0.75	
(I_D = 30 mAdc, V_{GS} = 0)	MFE2012		-	0.75	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MFE2010		-	25	
	MFE2011		-	15	
	MFE2012		-	10	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2010		-	25	
	MFE2011		-	15	
	MFE2012		-	10	
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	-	50	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	-	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1)		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		-	35	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	20	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	12	
Fall Time (See Figure 1)		t_f			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		-	75	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	45	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	25	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE2093 (SILICON)
MFE2094
MFE2095



PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD

CASE 20 (3)
(TO-72)

Silicon N-channel junction field-effect transistors, designed for low-power audio-amplifier and switching applications. Drain and source interchangeable.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

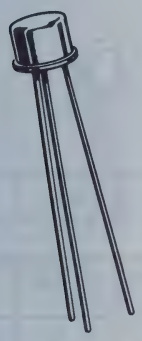
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	50	-	-	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	-	-	0.1	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	100	
Gate-Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	MFE2093	$V_{GS(off)}$	-	1.5	2.5	Vdc
	MFE2094		-	3.0	4.5	
	MFE2095		-	4.5	5.5	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE2093	I_{DSS}	0.1	0.35	0.7	mAdc
	MFE2094		0.4	0.7	1.4	
	MFE2095		1.0	1.5	3.0	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz) (1)	MFE2093	$\|y_{fs}\|$	250	400	500	μmhos
	MFE2094		350	500	700	
	MFE2095		400	600	800	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	MFE2093		150	-	-	
	MFE2094		250	-	-	
	MFE2095		300	-	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz) (1)	MFE2093	$\|y_{os}\|$	-	0.5	1.5	μmhos
	MFE2094		-	1.0	3.0	
	MFE2095		-	4.0	10.0	
Drain-Source Resistance (V_{DS} = 0, V_{GS} = 0)	MFE2093	$r_{ds(on)}$	-	2500	-	Ohms
	MFE2094		-	1600	-	
	MFE2095		-	1300	-	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{iss}	-	4.0	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	1.2	2.0	pF

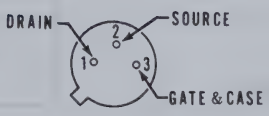
(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

MFE2133 (SILICON)



CASE 79 A
(TO-39 with 1½" leads)

N-channel junction silicon field-effect transistor designed for high-level chopper applications.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate-Drain Current	I_G	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.5 10	W mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	—	Vdc
Drain Cutoff Current (V_{DG} = 15 Vdc, I_S = 0)	I_{DGO}	—	—	1.0	nAdc
(V_{DG} = 15 Vdc, I_S = 0, T_A = 150°C)		—	—	1000	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	25	—	—	mAdc
Drain Cutoff Current (V_{DS} = 10 Vdc, V_{GS} = -10 Vdc)	$I_{D(off)}$	—	—	1.0	nAdc
(V_{DS} = 10 Vdc, V_{GS} = -10 Vdc, T_A = 150°C)		—	—	1000	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (1) (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	y_{fs}	12000	—	—	μmhos
Drain-Source Resistance (V_{GS} = 0, I_D = 0, f = 1 kHz)	$r_{ds(on)}$	—	40	60	ohms
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	14	20	pF
Reverse Transfer Capacitance (V_{GS} = -10 Vdc, V_{DS} = 0, f = 1 MHz)	C_{rss}	—	3.0	5.0	pF

(1) Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle = 10%

FIGURE 1 — DRAIN-SOURCE SATURATION REGION

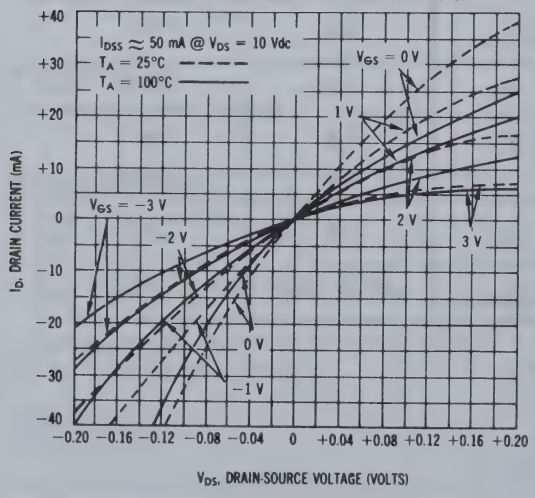
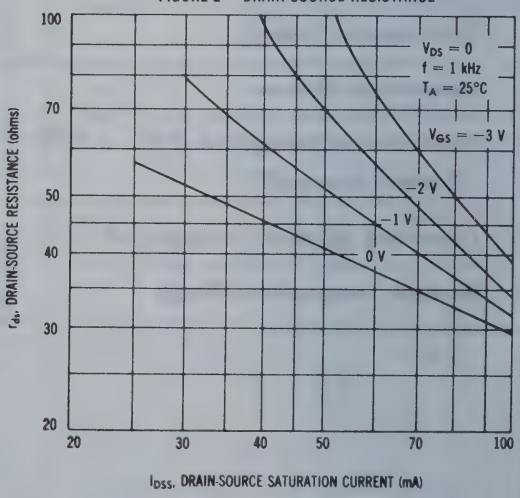


FIGURE 2 — DRAIN-SOURCE RESISTANCE



MFE3001 (SILICON)



CASE 20 (2)
(TO-72)

PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

Silicon N-channel insulated-gate field-effect transistor designed for low-power applications in the audio frequency range.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at T_A = 25°C Derating Factor above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -8 V, I_D = 10 μAdc)	BV_{DSX}	20	—	Vdc
Zero-Gate-Voltage Drain Current (V_{GS} = 0 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	0.5	6.0	mAdc
Gate-Source Voltage Cutoff (I_{DS} = 1 μAdc, V_{DS} = 10 Vdc)	$V_{GS(off)}$	—	-8.0	Vdc
ON CHARACTERISTICS				
"On" Drain Current (V_{GS} = 3.5 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	5.0	—	mAdc
Gate-Reverse Current* (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}*	—	10	pAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\|y_{fs}\|$	700	3500	μmhos
Output Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	1.5	pF

*This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

MFE3002 (SILICON)



Active Elements Isolated From Case

CASE 20(7)
(TO-72)

PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

Silicon N-channel MOS field-effect transistor designed for chopper applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate Connected to Source

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μAdc)	BV_{DSS}	15	-	Vdc
Gate Leakage Current (V_{GS} = 10 Vdc, V_{DS} = 0)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0) (V_{DS} = 10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	$V_{GS(TH)}$	-	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	100	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	1.0	pF

MFE3003 (SILICON)

Silicon P-channel MOS field-effect transistor designed for chopper applications.



CASE 20 (7)
(TO-72)

PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = -10 μAdc)	$V_{(BR)DSS}$	15	-	Vdc
Gate Leakage Current (V_{GS} = ±10 Vdc, V_{DS} = 0)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0) (V_{DS} = -10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage (V_{DS} = -10 Vdc, I_D = -10 μAdc)	$V_{GS(TH)}$	-	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = -10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	200	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)}$ = -10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	1.0	pF

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

MFE3004 (SILICON)
MFE3005



CASE 20(7)
(TO-72)

Silicon N-channel MOS field-effect transistors designed for VHF/UHF amplifier applications.

Active Elements Isolated From Case

PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -5.0 Vdc, I_D = 10 μAdc)	BV_{DSX}	20	-	Vdc
Gate-Source Cutoff Voltage (I_D = 10 μAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	5.0	Vdc
Gate Reverse Current (V_{GS} = ±15 Vdc, V_{DS} = 0)	I_{GSS}	-	50	pAdc
OFF CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	2.0	10	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	2000	-	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	0.2	pF
Small-Signal Power Gain (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, $R_S \approx$ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004	G_{ps}	16	-	dB
(V_{DS} = 15 Vdc, I_D = 2.0 mAdc, $R_S \approx$ 650 ohms, f = 400 MHz) (Figure 2) MFE3005		10	-	
Noise Figure (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, $R_S \approx$ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004	NF	-	4.5	dB
(V_{DS} = 15 Vdc, I_D = 2.0 mAdc, $R_S \approx$ 650 ohms, f = 400 MHz) (Figure 2) MFE3005		-	4.5	

FIGURE 1 — 200 MHz TEST CIRCUIT NEUTRALIZED

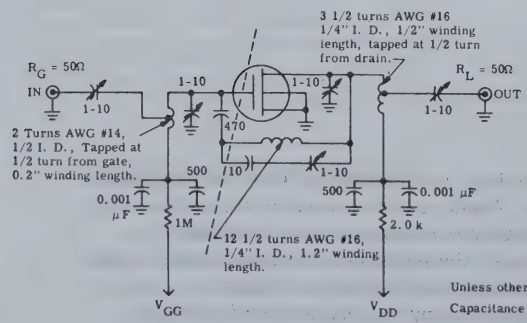
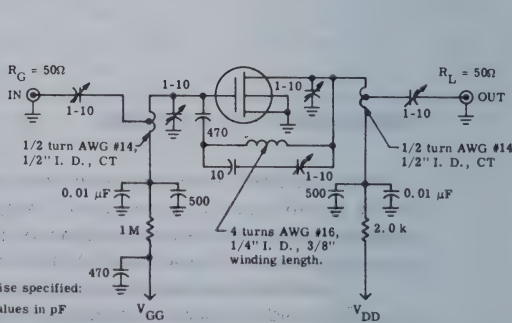


FIGURE 2 — 400 MHz TEST CIRCUIT NEUTRALIZED



Unless otherwise specified:
Capacitance values in pF

MFE3006 (SILICON)
thru
MFE3008

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

MFE3006 – RF Amplifier @ 100 MHz
MFE3007 – RF Amplifier @ 200 MHz
MFE3008 – Mixer @ 100 and 200 MHz

- Silicon Nitride Passivation for Excellent Long Term Stability
- High Common-Source Power Gain –
  MFE3006: G_{ps} = 20 dB (Min) @ f = 100 MHz
  MFE3007: G_{ps} = 18 dB (Min) @ f = 200 MHz
- High Common-Source Conversion Gain –
  MFE3008: G_{ps} = 14 dB (Min) @ f = 100 MHz
  G_{ps} = 10 dB (Min) @ f = 200 MHz
- Low Reverse Transfer Capacitance –
  C_{rss} = 0.02 pF (Typ) @ V_{DS} = 15 Vdc

N-CHANNEL

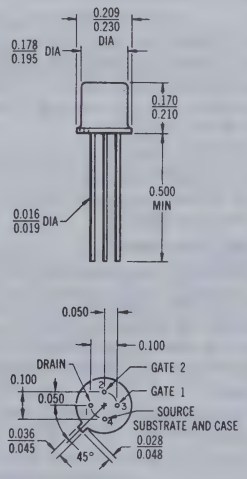
DUAL GATE MOS FIELD-EFFECT TRANSISTORS

TYPE B



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Gate 1 Source Voltage	V_{G1S}	±35	Vdc
Gate 2 Source Voltage	V_{G2S}	±35	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C



CASE 20 (9)
(TO-72)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

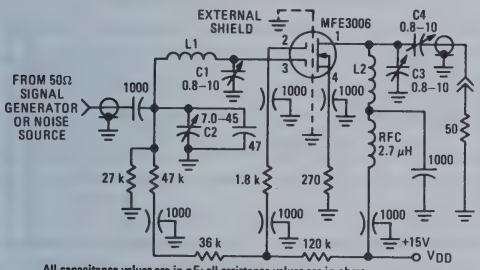
Substrate Connected to Source

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = V_{G2} = -4.0 Vdc)		$V_{(BR)DSX}$	25	–	–	Vdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)		$V_{G1S(off)}$	–	–	-3.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)		$V_{G2S(off)}$	–	–	-3.0	Vdc
Gate 1 Reverse Leakage Current		I_{G1SS}				nAdc
(V_{G1S} = -10 Vdc, V_{G2S} = 0, V_{DS} = 0)			–	–	1.0	
(V_{G1S} = -35 Vdc, V_{G2S} = 0, V_{DS} = 0)			–	–	10	
Gate 2 Reverse Leakage Current		I_{G2SS}				nAdc
(V_{G2S} = -10 Vdc, V_{G1S} = 0, V_{DS} = 0)			–	–	1.0	
(V_{G2S} = -35 Vdc, V_{G1S} = 0, V_{DS} = 0)			–	–	10	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current		I_{DSS}				mAdc
(V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	MFE3006		2.0	7.0	18	
	MFE3007		5.0	10	20	
	MFE3008		2.0	9.0	20	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (Gate 1 to Drain)		Y_{fs}				μmhos
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	MFE3006/8		8000	–	18,000	
	MFE3007		10,000	–	18,000	
Input Capacitance		C_{iss}				pF
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	MFE3006/8		–	4.5	6.0	
	MFE3007		–	4.5	5.5	
Output Capacitance		C_{oss}				pF
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	MFE3006/8		–	2.5	4.0	
	MFE3007		–	2.5	3.5	
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	–	0.02	–	pF
Common-Source Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, R_S = 1000 Ohms)						
f = 100 MHz, Figure 1	MFE3006		–	2.5	4.0	
f = 200 MHz, Figure 4	MFE3007		–	3.0	4.0	
Common-Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)						
f = 100 MHz, Figure 1	MFE3006		20	25	–	
f = 200 MHz, Figure 4	MFE3007		18	21	–	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)		–	–	100	–	mV
Common-Source Conversion Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, V_{G2S} = 0.5 Vdc, Local Oscillator Voltage = 3.0 Vrms)						
Signal Frequency = 100 MHz, Local Oscillator Frequency = 130 MHz, Figure 3	MFE3008		14	17	–	
Signal Frequency = 200 MHz, Local Oscillator Frequency = 230 MHz, Figure 6	MFE3008		10	13	–	

TEST CIRCUITS

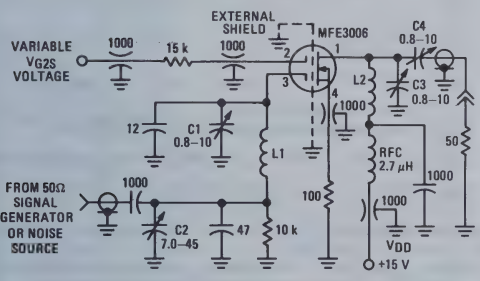
f = 100 MHz

FIGURE 1 – NOISE AND POWER GAIN



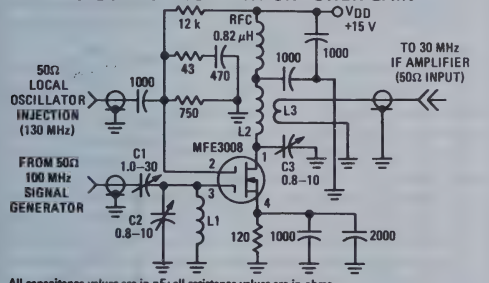
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16", Length 5/8")
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8", Length 5/8")
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 3.0 MHz @ -3.0 dB
4.5 MHz @ -6.0 dB

FIGURE 2 – GAIN REDUCTION



All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16", Length 5/8")
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8", Length 5/8")
Overall bandwidth = 3.0 MHz @ -3.0 dB
4.5 MHz @ -6.0 dB

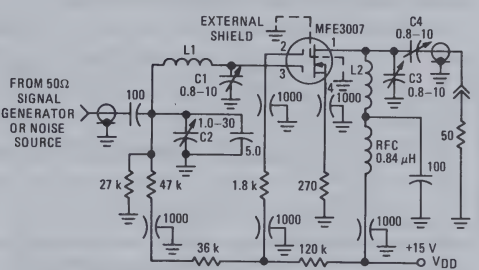
FIGURE 3 – CONVERSION POWER GAIN



All capacitance values are in pF; all resistance values are in ohms.
L1: 6 Turns #16 AWG Wire (Internal diameter 5/16", Length 7/16")
L2: 25 Turns #32 AWG Wire wound on 1/4" O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

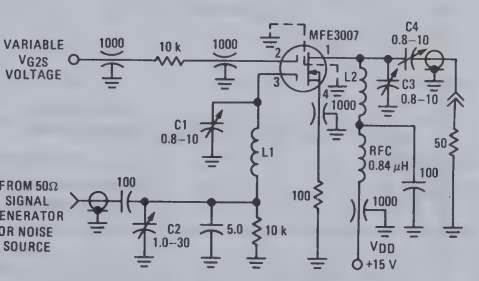
f = 200 MHz

FIGURE 4 – NOISE AND POWER GAIN



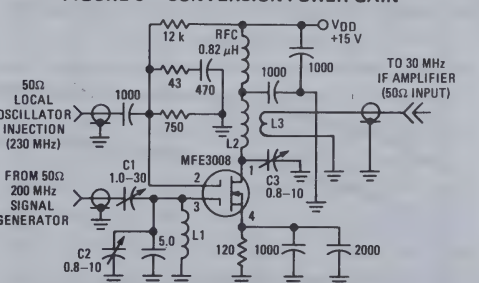
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 9.5 MHz @ -3.0 dB
14 MHz @ -6.0 dB

FIGURE 5 – GAIN REDUCTION



All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
Overall bandwidth = 9.5 MHz @ -3.0 dB
14 MHz @ -6.0 dB

FIGURE 6 – CONVERSION POWER GAIN



All capacitance values are in pF; all resistance values are in ohms.
L1: 2 Turns #16 AWG Wire (Internal diameter 1/4", Length 1/4")
L2: 25 Turns #32 AWG Wire wound on 1/4" O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

CIRCUIT PERFORMANCE

FIGURE 7 – POWER GAIN versus SOURCE RESISTANCE

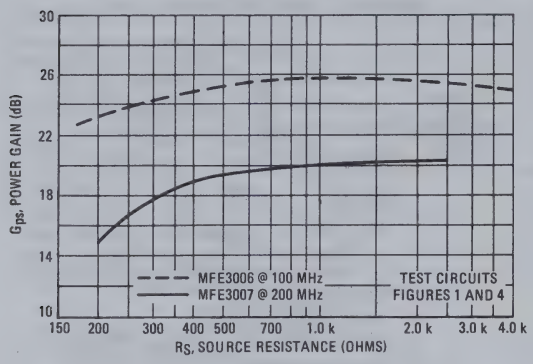


FIGURE 8 – NOISE FIGURE versus SOURCE RESISTANCE

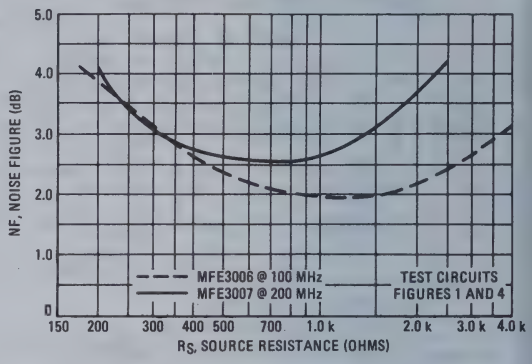


FIGURE 9 – GAIN REDUCTION

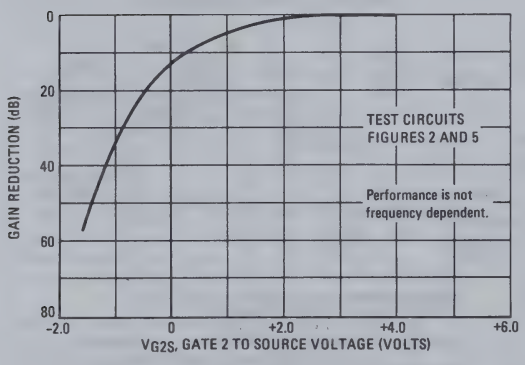


FIGURE 10 – COMMON SOURCE NOISE FIGURE versus GAIN REDUCTION

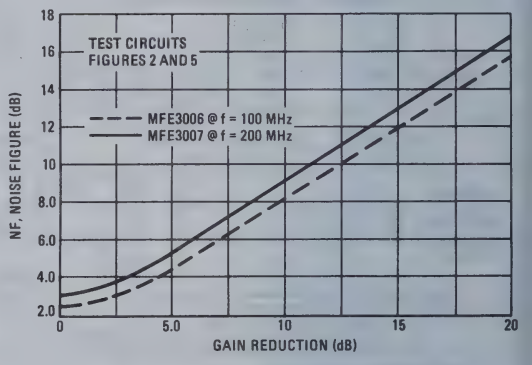


FIGURE 11 – CONVERSION POWER GAIN

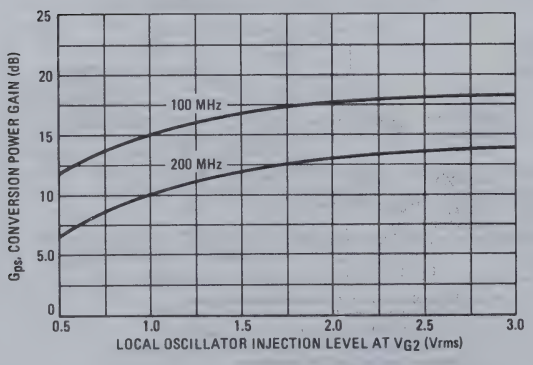
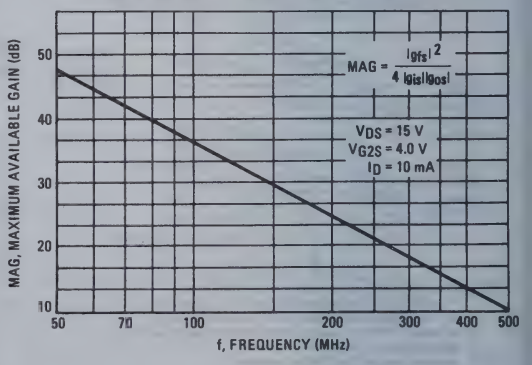


FIGURE 12 – MAXIMUM AVAILABLE POWER GAIN



COMMON-SOURCE ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 13 – INPUT ADMITTANCE

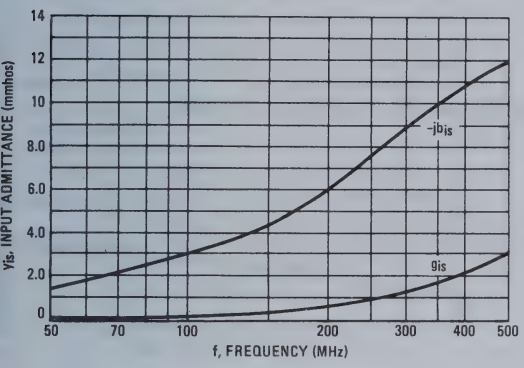


FIGURE 14 – REVERSE TRANSFER ADMITTANCE

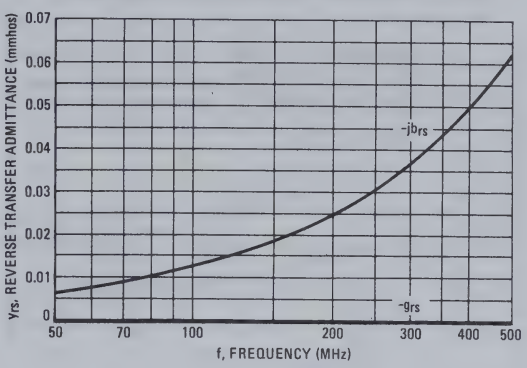


FIGURE 15 – FORWARD TRANSFER ADMITTANCE

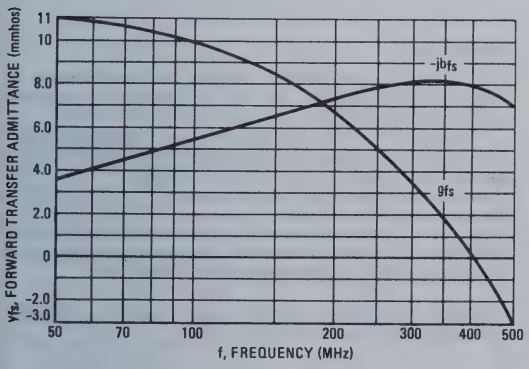
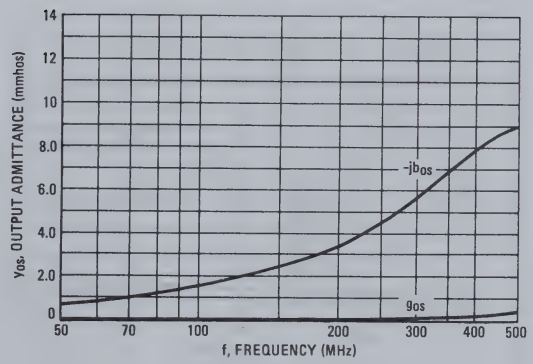


FIGURE 16 – OUTPUT ADMITTANCE



COMMON-SOURCE CIRCUIT DESIGN DATA AS A FUNCTION OF THE STERN "K" FACTOR

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 17 – TRANSDUCER POWER GAIN

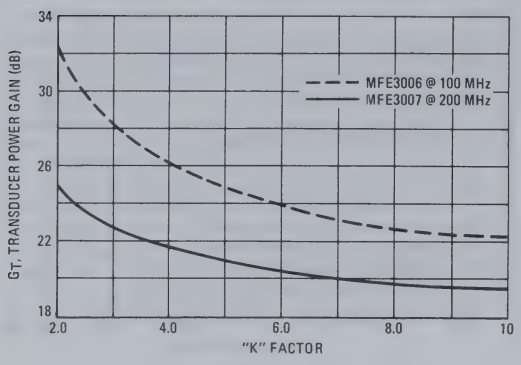


FIGURE 18 – SOURCE ADMITTANCE

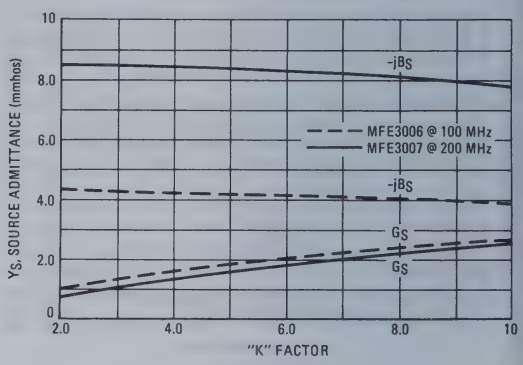
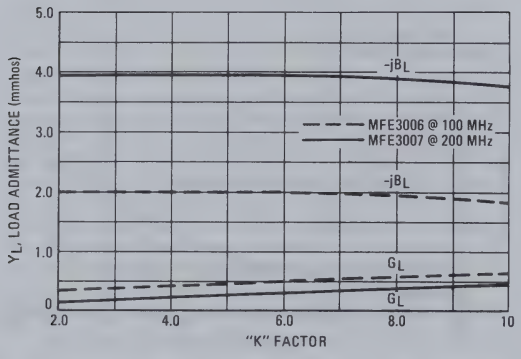


FIGURE 19 – LOAD ADMITTANCE



DESIGN NOTE

Figures 17-19 are included to assist the circuit designer in determining the transducer gain and the proper source and load admittances required for a given stability (Stern "K" factor*).

The Stern "K" factor has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

As the C_{rss} of the MFE3006-7 is comparable to the distributed capacitance of the circuit where it is used, a feedback capacitance of 0.1 pF has been used throughout these calculations.

*"Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

MFE3020 (SILICON)
MFE3021

DUAL P-CHANNEL
MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

- Low Reverse Gate Current —
  $I_{GSS} \leq 10$ pAdc @ $V_{GS} = -25$ Vdc
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)} = 250$ Ohms (Max) @ $V_{GS} = -15$ Vdc (MFE3021)

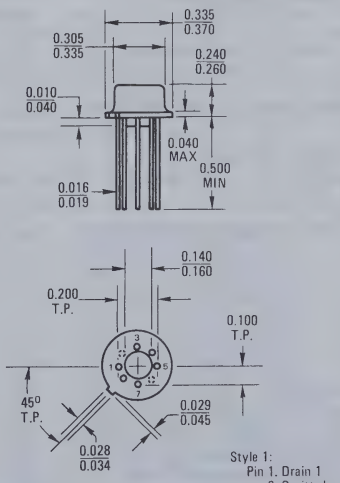
DUAL P-CHANNEL
MOS FIELD-EFFECT
TRANSISTORS

(Type C)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.6 4.0	Watt $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Operating Junction Temperature Range	T_J	-65 to +175	^oC



All JEDEC dimensions and notes apply

Style 1:
Pin 1. Drain 1
2. Omitted
3. Gate 1
4. Substrate
5. Gate 2
6. Omitted
7. Drain 2
8. Source 1

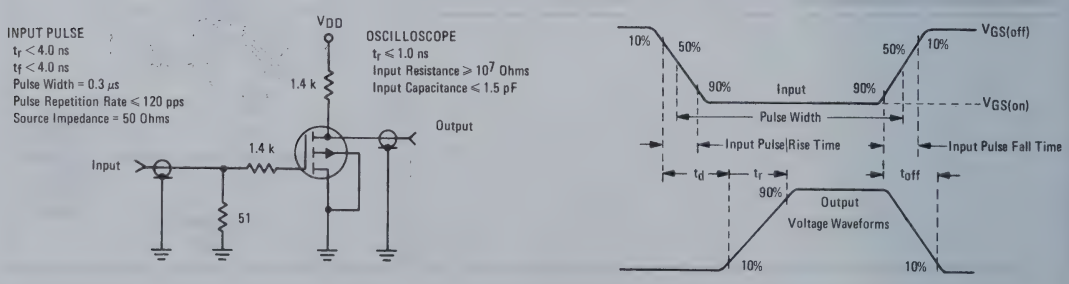
CASE 642
TO-76

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)	$V_{(BR)DSS}$	-25	–	Vdc
Source-Drain Breakdown Voltage (I_S = 10 μAdc, V_{GD} = 0)	$V_{(BR)SDS}$	-25	–	Vdc
Zero-Gate Voltage Source Current (V_{SD} = -15 Vdc, V_{GD} = 0)	I_{SDS}	–	10	nAdc
Zero-Gate Voltage Drain Current ① (V_{DS} = -15 Vdc, V_{GS} = 0)	I_{DSS}	–	10	nAdc
Gate Reverse Current (V_{GS} = -25 Vdc, V_{DS} = 0)	I_{GSS}	–	10	pAdc
ON CHARACTERISTICS				
Gate-Source Threshold Voltage (V_{DS} = -15 Vdc, I_D = 10 μAdc)	$V_{GS(th)}$	-2.0	-6.0	Vdc
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc)	$I_{D(on)}$	10	75	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = -15 Vdc, I_D = 0, f = 1.0 kHz) MFE3020 MFE3021	$r_{ds(on)}$	– –	500 250	Ohms
Forward Transadmittance ① (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)	$\|y_{fs}\|$	500	–	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 MHz)	C_{iss}	–	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.5	pF
Source-Substrate Capacitance (V_{DU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)	C_{SU}	–	5.0	pF
Drain-Substrate Capacitance (V_{SU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)	C_{DU}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{DD} = -15 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = -15 Vdc, $V_{GS(off)}$ = 0)	t_d	–	20	ns
Rise Time	t_r	–	30	ns
Turn-Off Time	t_{off}	–	50	ns

① Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1 – SWITCHING TIMES CIRCUIT



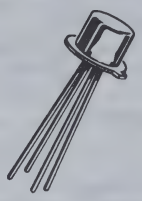
MFE4007 (SILICON)
thru
MFE4012

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type A) Field-Effect Transistors designed for general-purpose amplifier applications.

- Tightly Specified I_{DSS} Ranges – 2:1 for All Types
- High Gate-Source Breakdown Voltage – $V_{(BR)GSS}$ = 40 Vdc (Min) for All Types
- New Designers Data Sheet with Min/Max Curves for Ease in Design

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

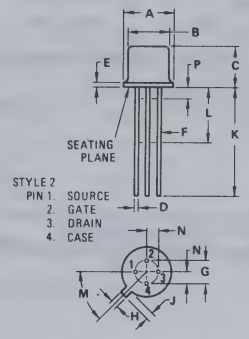


LIMIT DATA FOR "WORST CASE" DESIGNS

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves – representing boundaries for device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.33	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE4007, MFE4008	$V_{GS(off)}$	-	3.0	Vdc
	MFE4009, MFE4010		-	6.0	
	MFE4011, MFE4012		-	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	2.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE4007	I_{DSS}	0.5	1.0	mAdc
	MFE4008		0.8	1.6	
	MFE4009		1.5	3.0	
	MFE4010		2.5	5.0	
	MFE4011		4.0	8.0	
	MFE4012		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	MFE4007	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 80 μAdc)	MFE4008		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 150 μAdc)	MFE4009		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 250 μAdc)	MFE4010		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	MFE4011		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 700 μAdc)	MFE4012		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE4007	$\|y_{fs}\|$	900	2700	μmhos
	MFE4008		1000	3000	
	MFE4009		1500	3500	
	MFE4010		2000	4000	
	MFE4011		2200	4500	
	MFE4012		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	MFE4007	$Re(y_{fs})$	800	-	μmhos
	MFE4008		900	-	
	MFE4009		1400	-	
	MFE4010		1700	-	
	MFE4011		1900	-	
	MFE4012		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

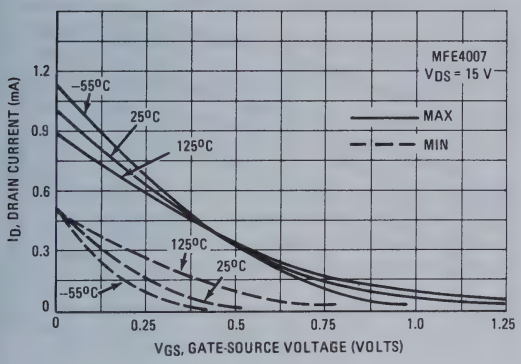


FIGURE 2

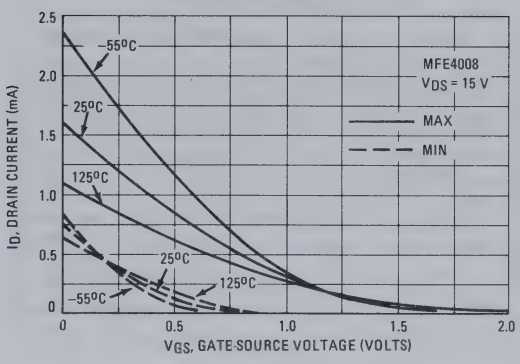


FIGURE 3

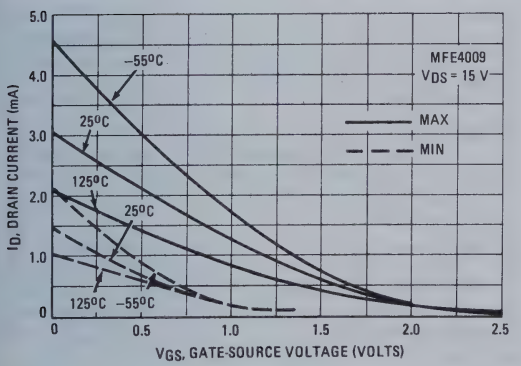


FIGURE 4

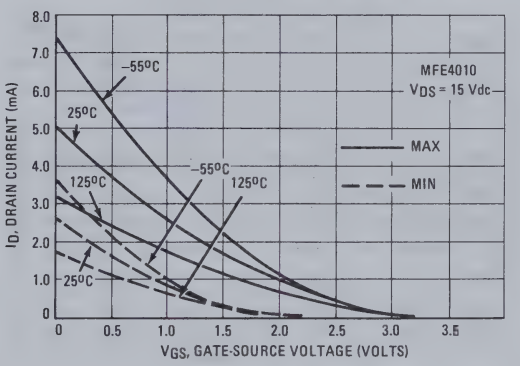


FIGURE 5

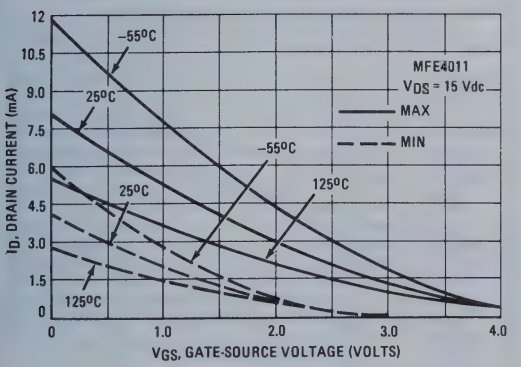
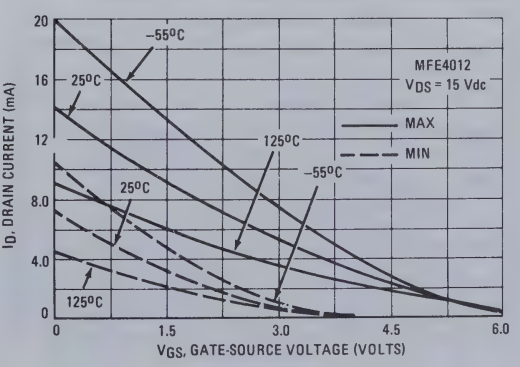


FIGURE 6



TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

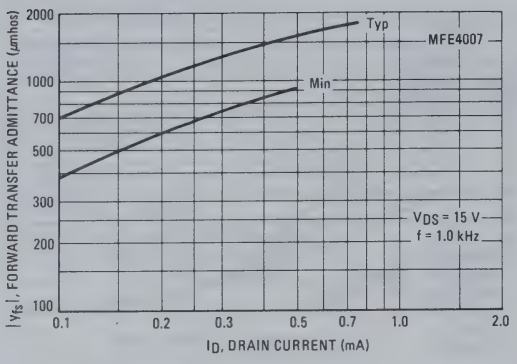


FIGURE 8

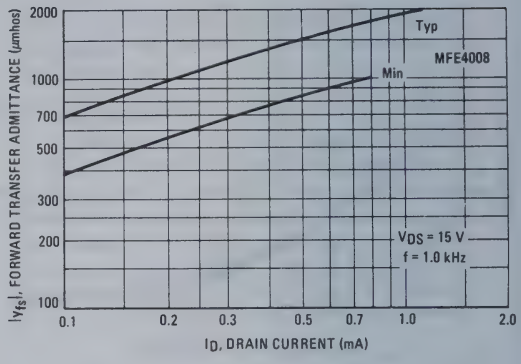


FIGURE 9

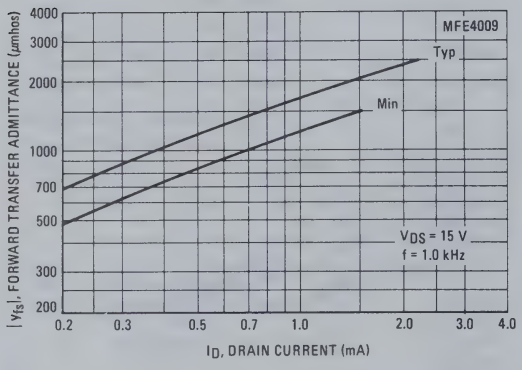


FIGURE 10

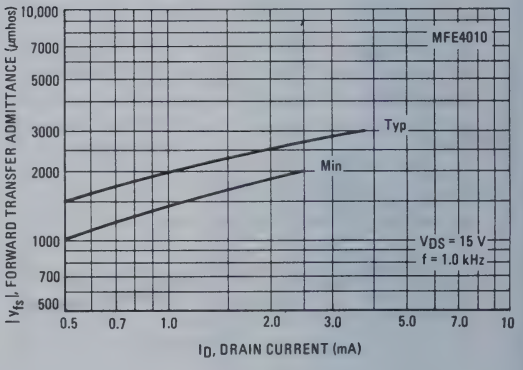


FIGURE 11

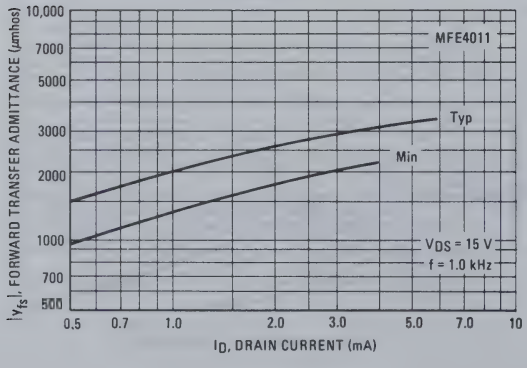
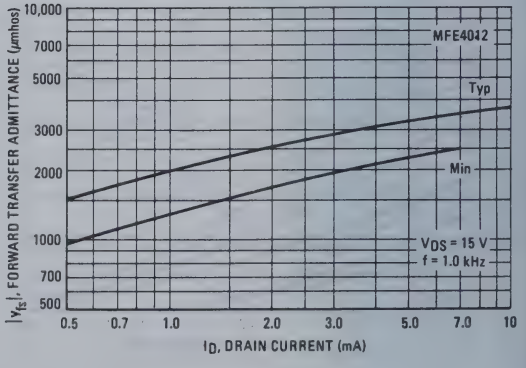


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

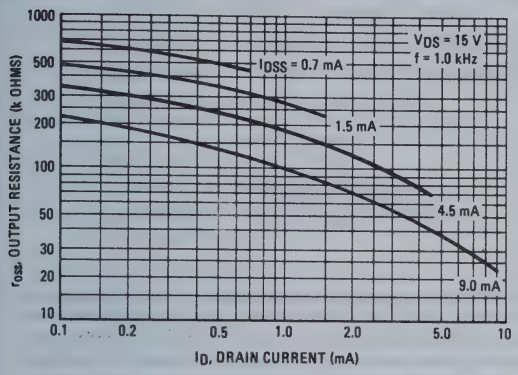


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

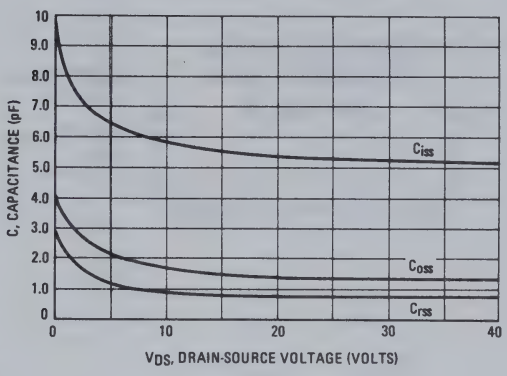


FIGURE 15 – NOISE FIGURE versus FREQUENCY

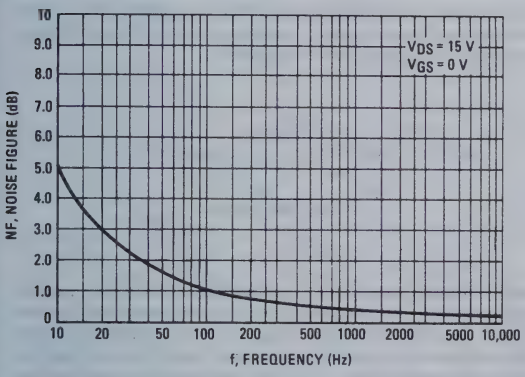


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

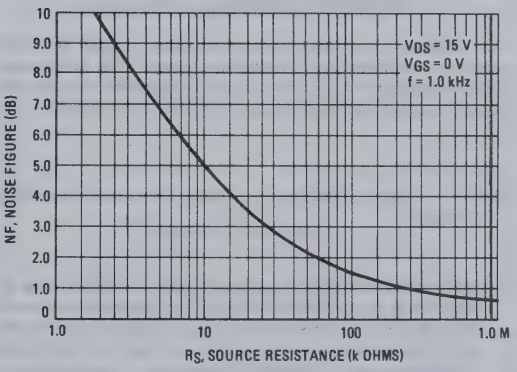


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

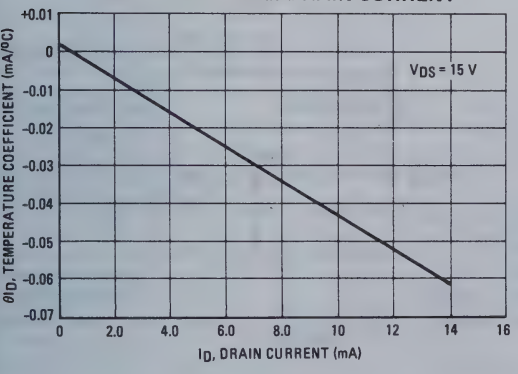


FIGURE 18 – TEMPERATURE COEFFICIENT versus DRAIN CURRENT

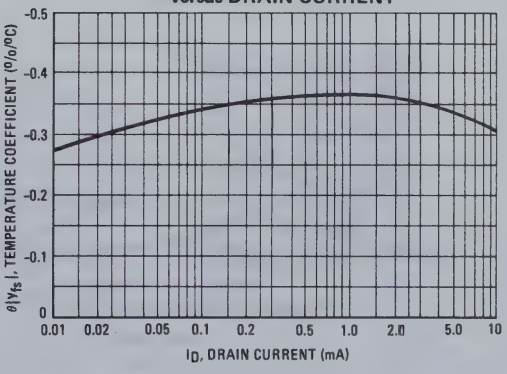
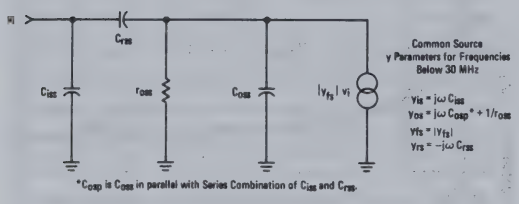


FIGURE 19 – EQUIVALENT LOW FREQUENCY CIRCUIT



$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9\ Vdc - 0.8\ Vdc}{(1.25\ mA - 0.75\ mA)} = 2.2\ k\ Ohms$$

$$V_G = \frac{I_{D(max)}\, V_{GS(min)} - I_{D(min)}\, V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \times 0.80 - 0.75 \times 1.9}{0.5} = -0.9\ Vdc$$

BIAS NETWORK DESIGN FOR WORST CASE I_{DSS} VARIANCE

This Designers Data Sheet has been published to assist the circuit designer in optimizing his "worst case" design. The following example illustrates the use of the forward transfer characteristics curves (Pigures 1 thru 6) in the design of a typical bias network.

Given: V_{DD} = -30 Vdc, I_D = 1.0 ± 0.25 mAdc from -55°C to +125°C

Procedure: The MFE4010 "worst case" bias conditions across the temperature range (from Figure 4) are reproduced in Figure A. The first step in the bias network design is to determine the value of the source resistance (R_S) necessary to hold the ± 0.25 mAdc I_D bias tolerance. To solve R_S, plot $I_{D(max)}$ and $I_{D(min)}$ on Figure A and calculate R_S, and V_G.

In Figure B the maximum allowable value for R_1 will be determined by loading due to gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, we can assume that it will double with each 15°C temperature rise. Therefore, we can assume a maximum reverse current of approximately 0.5 μAdc at 125°C, based on the specified maximum 2.0 μAdc reverse at 150°C. The variation in V_G bias versus temperature will not be too great if we chose a value for R_1 which results in a bias network current (I_1 in Figure B) greater than 5 times the maximum reverse current. Assuming a value for R_1 of 9.1 Megohms, R_2 can be solved from the equation:

$$V_G = -0.9\ Vdc \approx \frac{-30\ R_2}{9.1 + R_2}\ (\text{Ignoring } I_G)$$

$$R_2 \approx 300\ k\ Ohms$$

Using the above values of R_1 and R_2, the variation in V_G can be computed for I_G = 0 to I_G = 0.5 μAdc. V_G will vary from 0.81 Vdc at I_G = 0.5 μAdc to 0.96 Vdc @ I_G = 0. This variation will have a minimal effect on I_D, as can be seen from Figure A by plotting load lines with a slope equal to $1/R_S$ from V_G = 0.81 Vdc and 0.96 Vdc respectively.

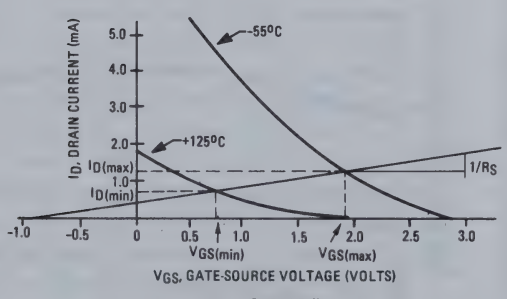


FIGURE A

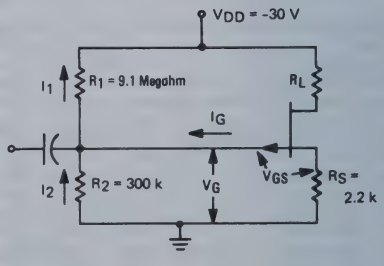


FIGURE B

MFE5000 (SILICON)

SILICON P-CHANNEL ENHANCEMENT MOS FIELD EFFECT QUAD TRANSISTOR

- Monolithic Construction Provides Improved Temperature Tracking
- Four Field Effect Transistors in One Package Cut Assembly Costs
- Diode Protected Gates
- Motorola's High Reliability Dual In-Line Ceramic Package

MOS FIELD-EFFECT QUAD TRANSISTOR P-CHANNEL

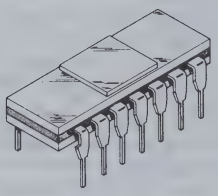
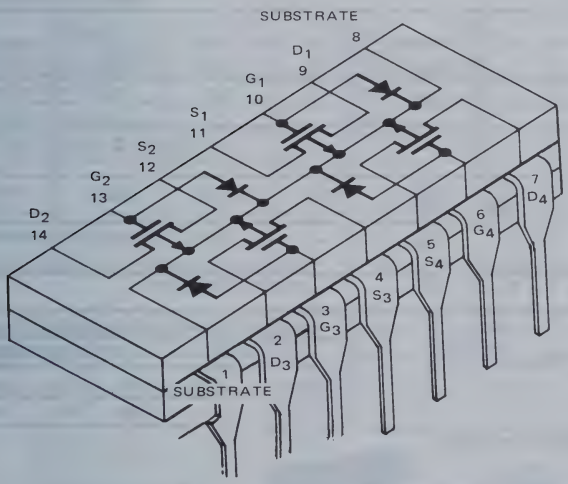
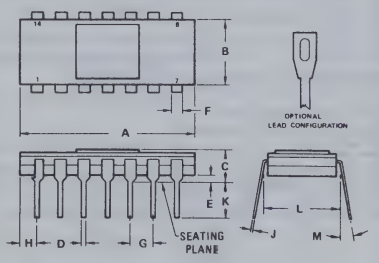


FIGURE 1 – SCHEMATIC DIAGRAM





MAXIMUM RATINGS For Each Individual Device

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	-25		Vdc
Drain-Gate Voltage	V_{DG}	±40		Vdc
Gate-Source Voltage	V_{GS}	±40		Vdc
Drain Current	I_D	50		mAdc
		Each Device	Total Package	
Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	250 1.66	450 3.0	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		^oC

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.730	0.760	18.540	19.300
B	0.240	0.260	6.100	6.600
C	–	0.200	–	5.080
D	0.015	0.023	0.380	0.580
E	0.020	–	0.510	–
F	0.030	0.070	0.760	1.780
G	0.100	BSC	2.540	BSC
H	0.075	TYP	1.910	TYP
J	0.008	0.015	0.200	0.380
K	0.115	0.135	2.920	3.430
L	0.290	0.310	7.370	7.870
M	–	15°	–	15°

NOTE:
DIMENSION "L" IS TO LEAD CENTERLINE WHEN FORMED PARALLEL.

CASE 605B-02

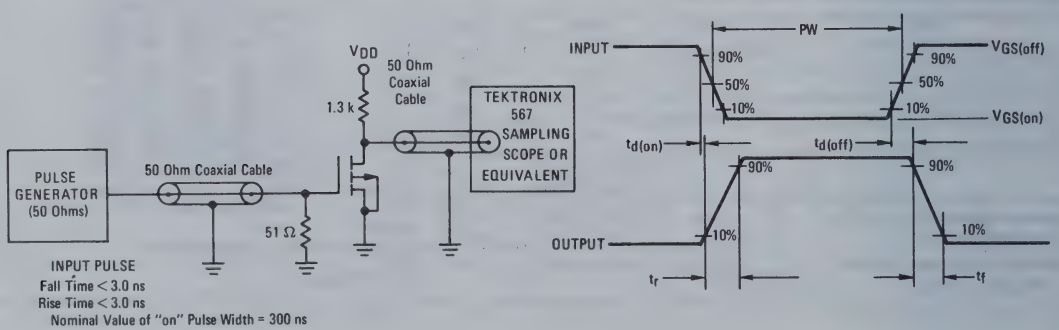
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) For Each FET

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = -10 μAdc)	$V_{(BR)DSS}$	25	–	–	Vdc
Gate Leakage Current (V_{GS} = -10 Vdc, V_{DS} = 0) (V_{GS} = -10 Vdc, V_{DS} = 0, T_A = 125°C)	I_{GSS}	– –	– –	1.0 1.0	nAdc μAdc
Gate-Drain Breakdown Voltage (V_{DSU} = 0, I_G = -10 μAdc)	$V_{(BR)GDS}$	50	100	125	Vdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc), V_{GS} = 0) (V_{DS} = -10 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	– –	1.0 1.0	10 10	nAdc μAdc
"ON" Drain Current (V_{DS} = - 5.0 Vdc, V_{GS} = -10 Vdc)	$I_{D(on)}$	10	–	50	mAdc
Drain-Source "ON" Voltage (I_D = 5.0 mAdc, V_{GS} = -10 Vdc)	$V_{DS(on)}$	–	1.0	1.5	Vdc
Gate-Source Threshold Voltage (V_{DS} = -10 Vdc, I_D = -10 μAdc)	$V_{GS(th)}$	1.0	4.0	5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = -10 Vdc, I_D = 0, f = 1.0 kHz) (V_{GS} = -25 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)1}$ $r_{ds(on)2}$	– –	175 75	225 110	Ohms
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	5.0	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	0.6	2.0	pF
Forward Transfer Admittance (V_{DS} = -10 Vdc, V_{GS} = -10 Vdc, f = 1.0 kHz)	$\lvert Y_{fs} \rvert$	2000	5000	8000	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = -10 Vdc, f = 1.0 kHz)	$\lvert Y_{os} \rvert$	–	400	1000	μmhos

SWITCHING CHARACTERISTICS

Turn-On Delay Time	(V_{DD} = -15 Vdc, I_D = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, See Figure 1)	$t_{d(on)}$	–	3.0	10	ns
Rise Time		t_r	–	10	20	ns
Turn-Off Delay Time		$t_{d(off)}$	–	5.0	10	ns
Fall Time		t_f	–	40	60	ns

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MHQ2221, MHQ2222 (SILICON)
MPQ2221, MPQ2222

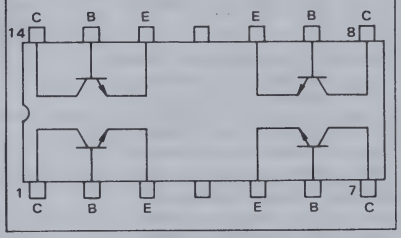
QUAD DUAL-IN-LINE NPN SILICON ANNULAR GENERAL-PURPOSE TRANSISTORS

. . . Designed for general-purpose switching circuits and DC to VHF amplifier applications.

- Choice of Ceramic or Plastic Package
- DC Current Gain Specified — 10 to 500 mAdc
- Low Collector-Cutoff Current — I_{CBO} = 10 nAdc (Max) @ V_{CB} = 50 Vdc
- High Collector Breakdown Voltages — BV_{CEO} = 40 Vdc (Min) BV_{CBO} = 60 Vdc (Min)
- Transistors Similar to 2N2218 thru 2N2222 Series
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment
- MHQ2221 Available With BV_{CEO} = 60 Vdc on Specified Request

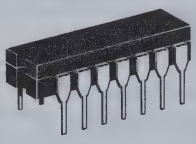
QUAD DUAL-IN-LINE NPN SILICON GENERAL-PURPOSE TRANSISTORS

CONNECTION DIAGRAM



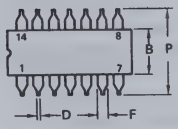
MAXIMUM RATINGS

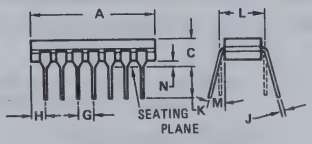
Rating	Symbol	Value		Unit
		Each Transistor	Total Device	
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2221, MHQ2222		3.72	10.88	mW/°C
Derate above 25°C MPQ2221, MPQ2222		6.5	19	mW/°C
Operating and Storage Junction Temperature Range MHQ2221,22	T_J,T_{stg}	-65 to +200		°C
Operating and Storage Junction Temperature Range MPQ2221,22		-55 to +125		°C



MHQ2221, MHQ2222

CERAMIC
CASE 632-02
TO-116

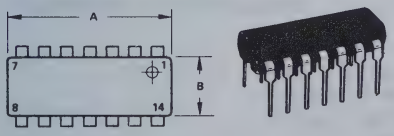




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

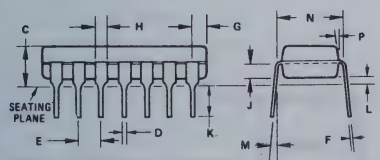
All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



MPQ2221, MPQ2222

PLASTIC
CASE 646
TO-116



*Dimension is to lead centerline when formed parallel.
All JEDEC dimensions and notes apply.

Weight ≈ 0.911 gram

1. DIM "N" TO LEAD CENTERLINE WHEN FORMED PARALLEL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.710	0.740	18.030	18.790
B	0.240	0.260	6.090	6.600
C	0.160	0.180	4.060	4.570
D	0.015	0.020	0.381	0.508
E	0.100 T P		2.54 T P	
F	0.009	0.014	0.228	0.355
G	0.060	0.080	1.520	2.030
H	0.040	0.065	1.020	1.650
J	0.062	0.072	1.570	1.830
K	0.115	0.135	2.920	3.430
L	0.025	0.035	0.635	0.889
M	0°	10°	0°	10°
N	0.290	0.310	7.360	7.870
P	7° TYP		7° TYP	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		35	–	–	
	MHQ2222, MPQ2222		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		40	–	–	
	MHQ2222, MPQ2222		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		20	–	–	
	MHQ2222, MPQ2222		30	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	4.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	17	30	pF
SWITCHING CHARACTERISTICS (Figure 1)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)		t_{on}	—	25	—	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)		t_{off}	—	250	—	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

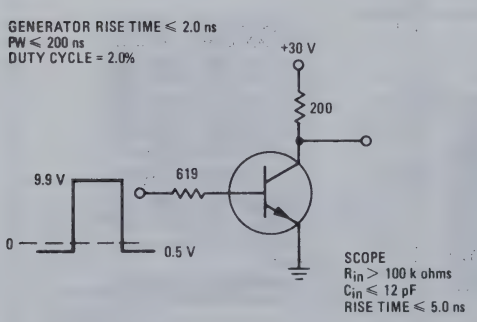
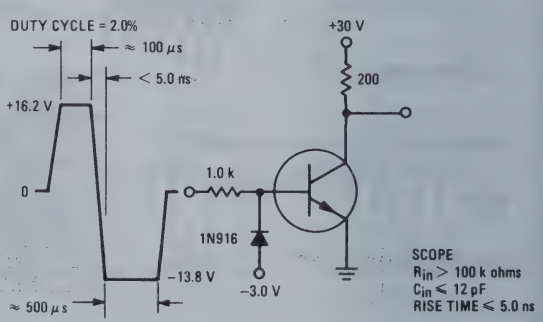


FIGURE 2 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



MHQ2369 (SILICON)
MPQ2369

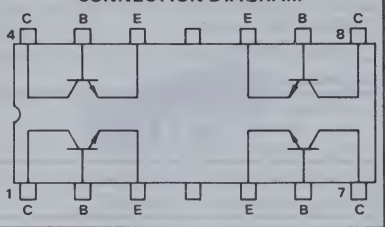
QUAD DUAL-IN-LINE NPN SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for low-current, high-speed switching and space saving applications.

- Choice of Ceramic or Plastic Package
- High Current-Gain–Bandwidth Product –
  f_T = 550 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times – @ V_{CC} = 3.0 Vdc
  t_{on} = 9.0 ns (Typ)
  t_{off} = 15 ns (Typ)
- Low Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Each Transistor Similar to 2N2369
- TO-116 Package – Compact Size Compatible With IC Automatic Insertion Equipment

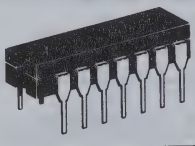
QUAD DUAL-IN-LINE NPN SILICON SWITCHING TRANSISTORS

CONNECTION DIAGRAM

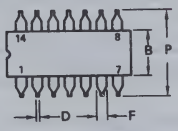


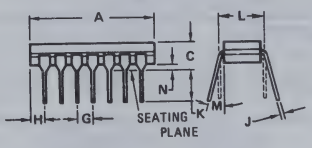
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Peak	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C	P_D	0.5	1.5	Watts
Derate above 25°C MHQ2369		2.86	8.58	mW/°C
Derate above 25°C MPQ2369		5.0	15	mW/°C
Operating and Storage Junction Temperature Range MHQ2369	T_J,T_{stg}	-65 to +200		°C
Operating and Storage Junction Temperature Range MPQ2369	T_J,T_{stg}	-55 to +125		°C



MHQ2369
CERAMIC
CASE 632-02
TO-116

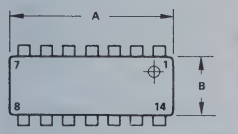


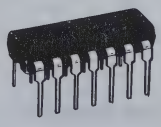


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

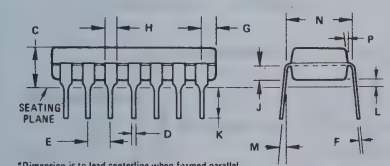
NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.





MPQ2221, MPQ2222

PLASTIC
CASE 646
TO-116



*Dimension is to lead centerline when formed parallel.
All JEDEC dimensions and notes apply.

Weight ≈ 0.911 gram

1. DIM "N" TO LEAD CENTERLINE WHEN FORMED PARALLEL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.710	0.740	18.030	18.790
B	0.240	0.260	6.090	6.600
C	0.160	0.180	4.060	4.570
D	0.015	0.020	0.381	0.508
E	0.100 T P		2.54 T P	
F	0.009	0.014	0.228	0.355
G	0.060	0.080	1.520	2.030
H	0.040	0.065	1.020	1.650
J	0.062	0.072	1.570	1.830
K	0.115	0.135	2.920	3.430
L	0.025	0.035	0.635	0.889
M	0°	10°	0°	10°
N	0.290	0.310	7.360	7.870
P	7° TYP		7° TYP	

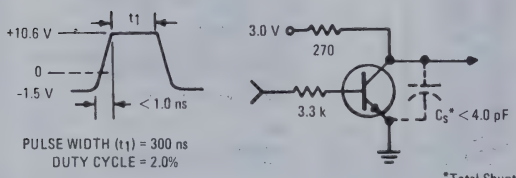
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	0.4	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	40 20	– –	– –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	2.5	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	9.0	–	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	15	–	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

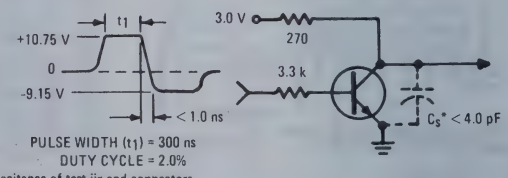
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – t_{on} CIRCUIT



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 – t_{off} CIRCUIT



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

*Total Shunt Capacitance of test jig and connectors.

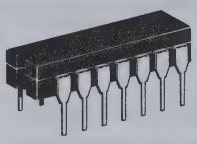
MHQ2483 (SILICON)
MHQ2484

QUAD DUAL-IN-LINE
NPN HERMETIC SILICON ANNULAR
AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure – @ I_C = 10 μAdc
  NF = 3.0 dB (Typ) – MHQ2483
  = 2.0 dB (Typ) – MHQ2484
- Transistors Similar to 2N2483 and 2N2484
- TO-116 Ceramic Package – Compact Size Compatible with I_C Automatic Insertion Equipment

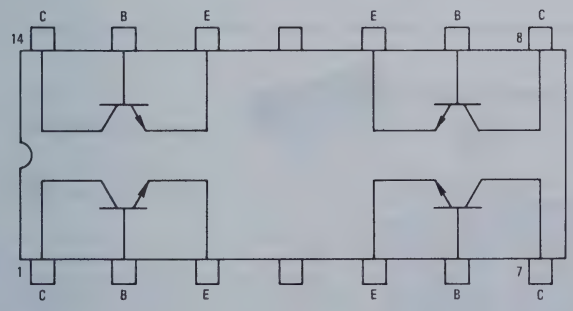
QUAD DUAL-IN-LINE
NPN SILICON
AMPLIFIER
TRANSISTORS

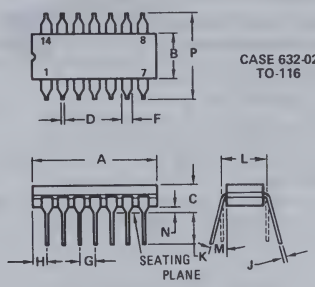


MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.42	1.8 10.3	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	4.2 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483		100	–	–	
	MHQ2484		200	–	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483		150	–	–	
	MHQ2484		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483		150	–	–	
	MHQ2484		300	–	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.15	0.5	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			–	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			–	0.70	0.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	–	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	1.8	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	4.0	8.0	pF
Noise Figure		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms,	MHQ2483		–	3.0	–	
f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MHQ2484		–	2.0	–	

MHQ2906, MHQ2907 (SILICON)
MPQ2906, MPQ2907

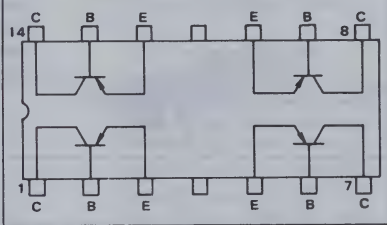
QUAD DUAL-IN-LINE
PNP SILICON ANNULAR
GENERAL-PURPOSE TRANSISTORS

. . . designed for general-purpose switching circuits and DC to VHF amplifier applications.

- Choice of Ceramic or Plastic Package
- High Collector-Base Breakdown Voltage — BV_{CBO} = 60 Vdc (Min) @ I_C = 10 μAdc
- DC Current Gain Specified — 10 to 300 mAdc
- High Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 50 mAdc
- Transistors Similar to 2N2906 and 2N2907
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment

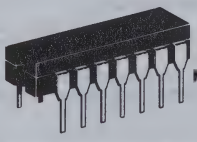
QUAD DUAL-IN-LINE
PNP SILICON
GENERAL-PURPOSE
TRANSISTORS

CONNECTION DIAGRAM

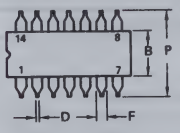


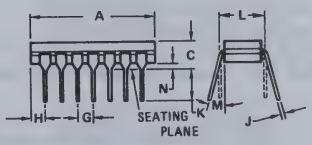
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2906, MHQ2907		3.72	10.88	mW/°C
MPQ2906, MPQ2907		6.5	19	
Operating and Storage Junction Temperature Range MHQ2906,07 MPQ2906,07	T_J,T_{stg}	-65 to +200 -55 to +125		°C



MHQ2906, MHQ2907
CERAMIC
CASE 632-02
TO-116

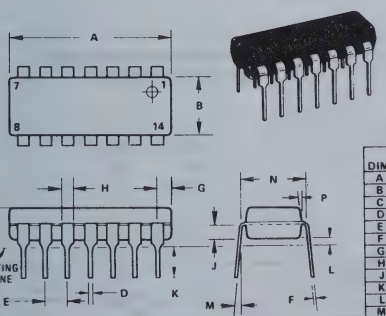




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



*Dimension is to lead centerline when formed parallel.
All JEDEC dimensions and notes apply.

Weight = 0.911 gram

MPQ2906, MPQ2907
PLASTIC
CASE 646
TO-116

1. DIM "N" TO LEAD CENTERLINE WHEN FORMED PARALLEL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.710	0.740	18.030	18.790
B	0.240	0.260	6.090	6.600
C	0.160	0.180	4.060	4.570
D	0.015	0.020	0.381	0.508
E	0.100 T P		2.54 T P	
F	0.009	0.014	0.228	0.355
G	0.060	0.080	1.520	2.030
H	0.040	0.065	1.020	1.650
J	0.062	0.072	1.570	1.830
K	0.115	0.135	2.920	3.430
L	0.025	0.035	0.635	0.889
M	0°	10°	0°	10°
N	0.290	0.310	7.360	7.870
P	7° TYP		7° TYP	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		35	–	–	
	MHQ2907, MPQ2907		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		40	–	–	
	MHQ2907, MPQ2907		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		30	–	–	
	MHQ2907, MPQ2907		50	–	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.6	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	20	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)		t_{on}	–	30	–	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)		t_{off}	–	100	–	ns

(1) **Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.**

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

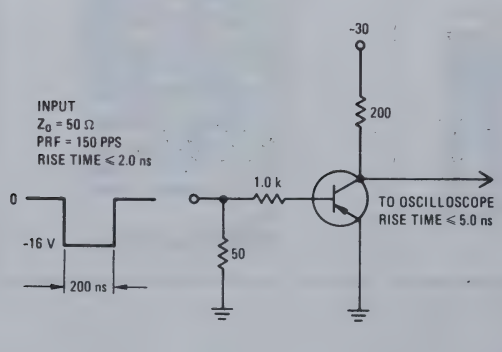
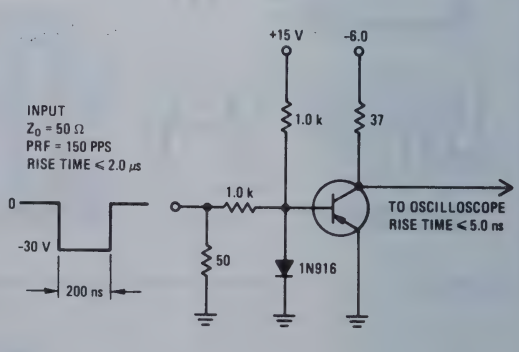


FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT



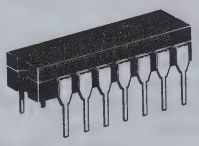
MHQ3467 (SILICON)

QUAD DUAL-IN-LINE PNP HERMETIC SILICON ANNULAR MEMORY DRIVER TRANSISTORS

. . . designed for medium-current, high-speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc
- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Transistors Similar to 2N3467
- TO-116 Ceramic Package — Compact Size Compatible With IC Automatic Insertion Equipment

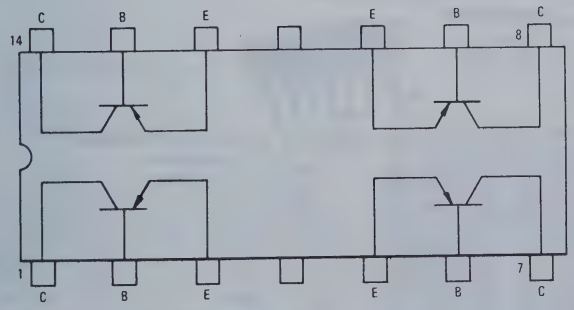
QUAD DUAL-IN-LINE PNP SILICON MEMORY DRIVER TRANSISTORS

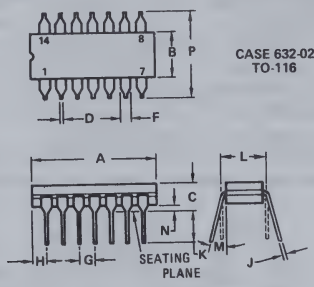


MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.9 5.13	2.7 15.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	6.3 36	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−55 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

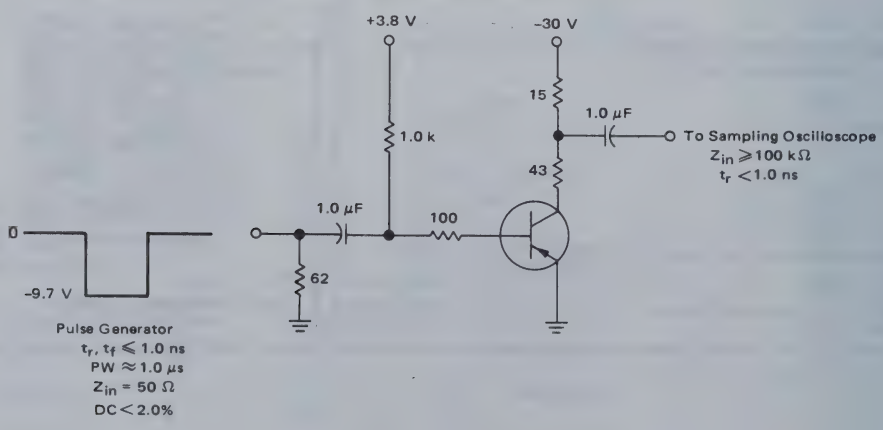
NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	0.9	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain — Bandwidth Products (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	80	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	–	40	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	–	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MHQ3546 (SILICON)
MPQ3546

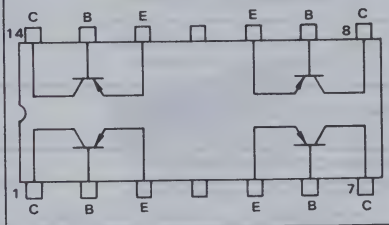
QUAD DUAL-IN-LINE PNP SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for low-level, high-speed switching applications.

- Choice of Ceramic or Plastic Package
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times
  t_{on} = 9.0 ns (Typ)
  t_{off} = 20 ns (Typ)
- Transistor Similar to 2N3546
- TO-116 Packaging – Compact Size Compatible With IC Automatic Insertion Equipment

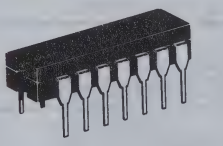
QUAD DUAL-IN-LINE PNP SILICON SWITCHING TRANSISTOR

CONNECTION DIAGRAM

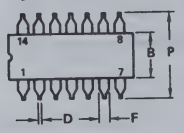


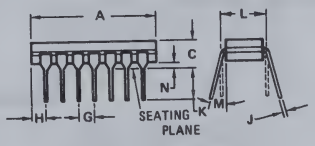
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CB}	15		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Continuous	I_C	200		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C	P_D	0.5	1.5	Watts
Derate above 25°C MHQ3546		2.86	8.58	mW/°C
Derate above 25°C MPQ3546		5.0	15	mW/°C
Operating and Storage Junction Temperature Range MHQ3546	T_J, T_{stg}	-65 to +200		°C
Operating and Storage Junction Temperature Range MPQ3546		-55 to +125		°C



MHQ3546
CERAMIC
CASE 632-02
TO-116

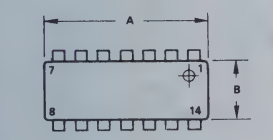




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
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G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

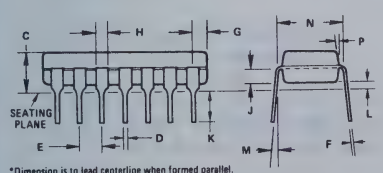
All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.





MPQ3546
PLASTIC
CASE 646
TO-116



*Dimension is to lead centerline when formed parallel.
All JEDEC dimensions and notes apply.

Weight ≈ 0.911 gram

1. DIM "N" TO LEAD CENTERLINE WHEN FORMED PARALLEL.

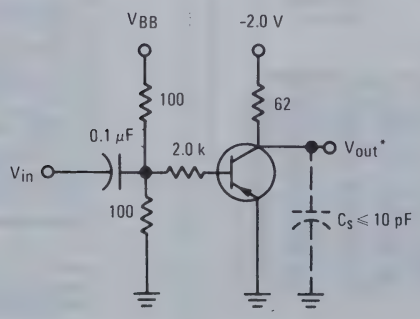
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.710	0.740	18.030	18.790
B	0.240	0.260	6.090	6.600
C	0.160	0.180	4.060	4.570
D	0.015	0.020	0.381	0.508
E	0.100 T P		2.54 T P	
F	0.009	0.014	0.228	0.355
G	0.060	0.080	1.520	2.030
H	0.040	0.065	1.020	1.650
J	0.062	0.072	1.570	1.830
K	0.115	0.135	2.920	3.430
L	0.025	0.035	0.635	0.889
M	0°	10°	0°	10°
N	0.290	0.310	7.360	7.870
P	7° TYP		7° TYP	

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	–	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	3.5	8.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)	t_{on}	–	15	–	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_{off}	–	25	–	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



PULSE WIDTH > 200 ns
RISE TIME < 1.0 ns
Z_{in} = 50 Ω

t_{on}: V_{BB} = +3.0 V, V_{in} = -7.0 Vdc
t_{off}: V_{BB} = -4.0 V, V_{in} = +6.0 Vdc

*Oscilloscope Rise Time ≤ 1.0 ns

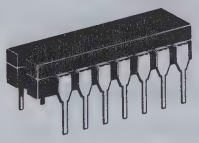
MHQ3798 (SILICON)
MHQ3799

QUAD DUAL-IN-LINE
PNP HERMETIC SILICON ANNULAR
AMPLIFIER TRANSISTORS

. . . designed for low-level, low-noise amplifier applications.

- Low DC Current Gain Specified – 10 μAdc to 10 mAdc
  h_{FE} = 150 (Min) @ I_C = 500 μAdc – MHQ3798
  = 300 (Min) @ I_C = 500 μAdc – MHQ3799
- Low Capacitance –
  C_{ob} = 2.3 pF (Typ) @ V_{CB} = 5.0 Vdc
- Low Noise Figure – NF = 2.5 dB (Typ) @ I_C = 100 μAdc
- Transistors Similar to 2N3798 and 2N3799
- TO-116 Ceramic Packaging – Compact Size Compatible With IC Automatic Insertion Equipment

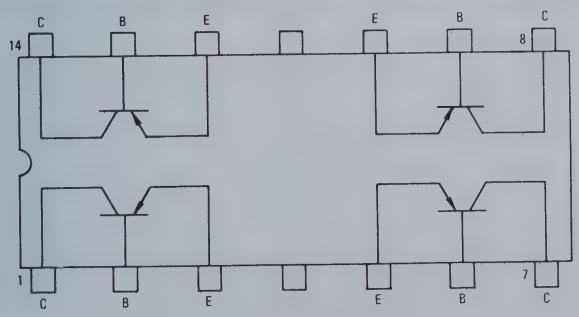
QUAD DUAL-IN-LINE
PNP SILICON
AMPLIFIER TRANSISTORS

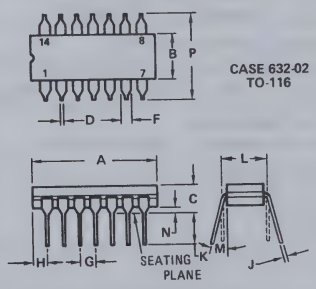


MAXIMUM RATINGS

Rating	Symbol	MHQ3798	MHQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ3798	BV_{CEO}	40	–	–	Vdc
	MHQ3799		60	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798	h_{FE}	100	–	–	–
	MHQ3799		225	–	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798		150	–	–	
	MHQ3799		300	–	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798		150	–	–	
	MHQ3799		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ3798		125	–	–	
	MHQ3799		250	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$	–	–	0.2	Vdc
(I_C = 1.0 mAdc, I_B = 100μ Adc)			–	–	0.25	
Base-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$	–	–	0.7	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	–	0.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	–	130	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.3	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	5.5	–	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k Ohms, f = 10 Hz to 15.7 kHz)	MHQ3798	NF	–	2.5	–	dB
	MHQ3799		–	1.5	–	

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

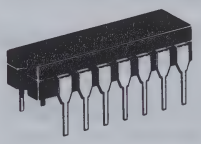
MHQ6001 (SILICON)
MHQ6002

QUAD DUAL-IN-LINE HERMETIC SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified — 1.0 to 300 mAdc
- High Current-Gain—Bandwidth Product — f_T = 400 MHz (Typ) @ I_C = 50 mAdc
- NPN Transistors Similar to 2N2218 or 2N2219
- PNP Transistors Similar to 2N2904 or 2N2905
- TO-116 Ceramic Package — Compact Size Compatible With IC Automatic Insertion Equipment

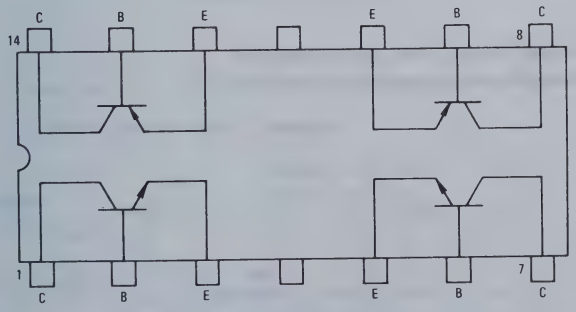
QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS

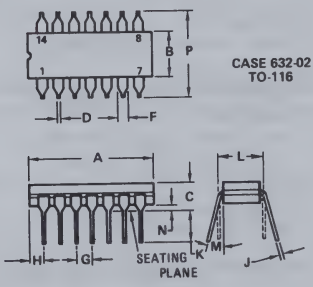


MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 3.72	1.9 10.88	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.3 7.43	4.6 26.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc	MHQ6001		25	–	–	
	MHQ6002		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ6001		35	–	–	
	MHQ6002		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ6001		40	–	–	
	MHQ6002		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ6001		20	–	–	
	MHQ6002		30	–	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.4	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 kHz)		f_T	–	400	–	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	NPN		–	6.0	–	
	PNP		–	4.5	–	
Input Capacitance		C_{ib}				pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	NPN		–	20	–	
	PNP		–	17	–	
SWITCHING CHARACTERISTICS (Figure 1)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	–	30	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	–	225	–	ns
			–		–	

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse the diodes, voltage polarities, and input pulses.

FIGURE 1 – NPN TURN-ON TIME

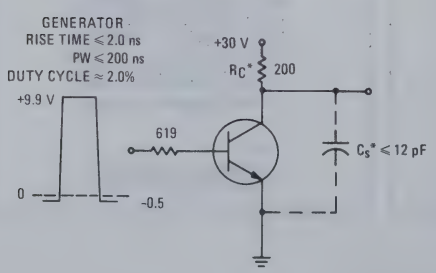
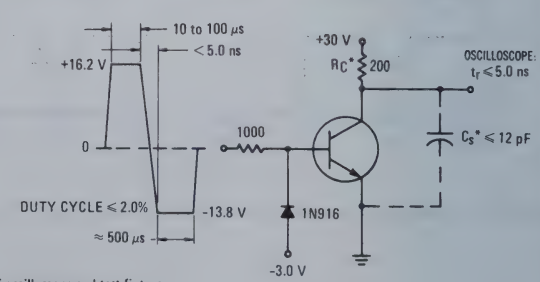


FIGURE 2 – NPN TURN-OFF TIME



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

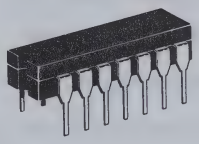
MHQ6100 (SILICON)
MHQ6100A

QUAD DUAL-IN-LINE HERMETIC SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for complementary circuits where low-level, low-noise amplification is required.

- Low Collector Cutoff Current — I_{CBO} = 10 nAdc (Max) @ V_{CB} = 50 Vdc
- PNP Transistor Similar to 2N3798
- NPN Transistor Similar to 2N930
- TO-116 Ceramic Packaging — Compact Size Compatible With IC Automatic Insertion Equipment

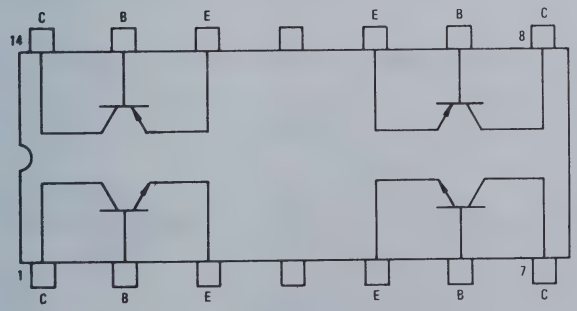
QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS

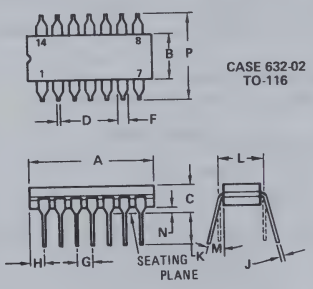


MAXIMUM RATINGS

Rating	Symbol	MHQ6100	MHQ6100A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ6100	BV_{CEO}	40	–	–	Vdc
	MHQ6100A		45	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100		50	–	–	
	MHQ6100A		100	–	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100		75	–	–	
	MHQ6100A		150	–	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100		75	–	–	
	MHQ6100A		150	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100		60	–	–	
	MHQ6100A		125	–	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	–	–	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	NPN	f_T	–	175	–	MHz
	PNP		–	130	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	NPN	C_{ob}	–	4.5	–	pF
	PNP		–	2.3	–	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	NPN	C_{ib}	–	6.0	–	pF
	PNP		–	5.5	–	

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

MHW559

The RF Line

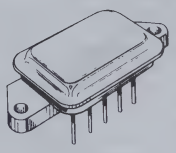
LOW NOISE WIDEBAND AMPLIFIER MODULE

. . . designed for preamplifier applications in CATV bridger, and trunk amplifiers.

- Frequency Range – 40 to 300 MHz
- Power Gain – 15 dB (Min)
- Output Capability – 47 dBmV (21 channel)
- Noise Figure – 7.5 dB (Max)
- $T_{C(max)}$ = 80°C (measured at Mounting Flange)
- Hermetic Package

WIDEBAND AMPLIFIER MODULE

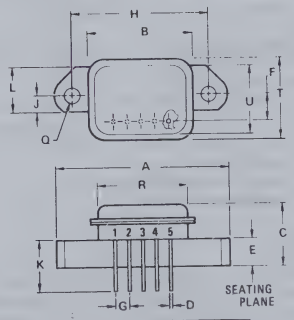
40-300 MHz



ELECTRICAL SPECIFICATIONS (V_{CC} = 24 Vdc)

Parameter	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	–	300	MHz
Power Gain	Gp	15	16	17	dB
Gain Flatness (Figure 3)	–	–	±0.2	±0.3	dB
Output Capability 21 Channel 12 Channel	E_{out}(1)	 47 49.5	 – –	 – –	dBmV
Second Order Distortion (Intermodulation Distortion) @ +47 dBmV	IMD	–	–	-69	dB
Triple Beat @ +47 dBmV	TB	–	–	-76	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	16	18	–	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	16	18	–	dB
Noise Figure	NF	–	7.0	7.5	dB
Power Dissipation (B+ = 24 Vdc, T_C = 30°C)	P_D	–	–	5.0	Watts

(1) To NCTA Specification, @ -57 dB Cross Modulation Distortion.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	46.99	48.01	1.850	1.890
B	29.46	30.48	1.160	1.200
C	14.35	15.11	0.565	0.595
D	0.69	0.84	0.027	0.033
E	4.95	5.46	0.195	0.215
F	7.62	7.87	0.300	0.310
G	4.06 BSC		0.160 BSC	
H	37.97	38.23	1.495	1.505
J	4.57	4.83	0.180	0.190
K	9.14	10.16	0.360	0.400
L	12.57	12.83	0.495	0.505
Q	3.99	4.24	0.157	0.167
R	24.94	25.19	0.982	0.992
T	23.11	24.13	0.910	0.950
U	18.47	18.72	0.727	0.737

CASE 270-01

STYLE 1
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

FIGURE 1 – TYPICAL APPLICATION IN TRUNK AMPLIFIER

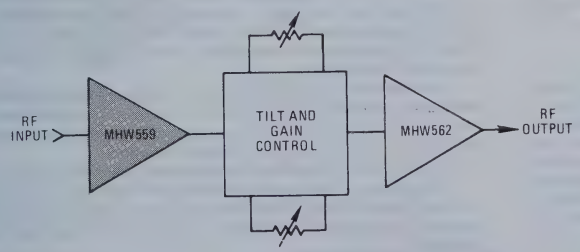


FIGURE 2 – OUTPUT CAPABILITY TEST METHOD

The following block diagram, is used for measuring cross modulation distortion:

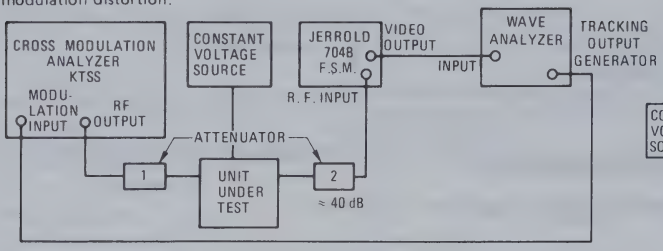
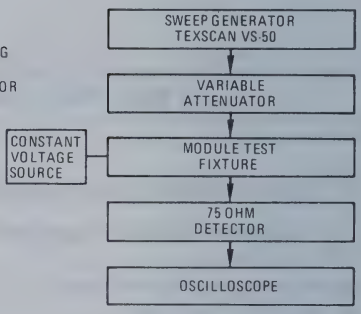


FIGURE 3 – GAIN FLATNESS TEST



The controls on the above test equipment shall be set as follows:

Field Strength Meter – 704B

1. Range Switch — manual
2. Input Attenuator — both switched out

Wave Analyzer – BR 1900A

1.	Mode	Tracking Generator
2.	Bandwidth	10 Hz
3.	Meter Speed	Medium (see operation information)
4.	Frequency	15.750 kHz
5.	Reading	Relative
6.	Gain	Set for a full scale reading (see operation information)
7.	Level	Maximum Clockwise
8.	Tracking Generator Output	Connect to KTSS "modulation input"

Cross Modulation Analyzer – KTSS

1.	Main power switch	ON
2.	Modulation selector switch	External (see operation information)
3.	Desired Channel Module Power Switch	ON
4.	Desired Channel Module Modulation Switch	ON

Operation

With the equipment set-up as shown in Figure 2, switch the desired channel power switches ON. Set Attenuator 1 in combination with the channel module RF OUTPUT controls for desired levels from the unit-under-test. Set Attenuator 2 for approximately 40 dB attenuation. Caution should be taken to insure that the signal level into the field strength meter (FSM) is such that no distortion occurs in the meter itself. Adjust manual gain control on FSM such that the dc level out of the video output is 2.0 V dc when the meter is turned to the unmodulated RF carrier to be tested. For these conditions the Jerrold 704B will give optimum cross modulation results. When measuring cross modulation on a particular channel, set a modulation reference for a full scale reading on the 3-volt wave analyzer scale. Adjust for a full scale reading by using the GAIN control on the wave analyzer.

After setting a moudlation reference, switch the module modulation switch OFF. Increase the input sensitivity of the wave analyzer until the reading is near the mid-scale range on the wave analyzer meter. On lower levels, the meter speed switch can be set to SLOW, so that noise spikes will not interfere with the measurement. Cross modulation is the amount of attenuation removed from the meter range plus the meter scale difference from reference. Reduce the input sensitivity to what it formerly was and switch the module modulation switch back to ON. Repeat this process for each channel to be measured.

Procedure

1. Initially, connect the Variable Attenuator to the 75-Ohm Detector. Adjust the sweep generator to cover the desired frequency range and the variable attenuator to give a convenient reference trace on the oscilloscope.
2. Insert the module test fixture between the attenuator and detector. Add 15 dB of attenuation in the variable attenuator.
3. Determine the deviation from flatness and desired gain by removing or inserting attenuation with the variable attenuator and comparing the module response with the reference trace.
4. Alternate test methods, such as the use of a coaxial switcher may be employed.

SECOND ORDER DISTORTION TEST METHOD

Insert 70 dB of attenuation between the unit-under-test and the field strength meter. Set the field strength meter sensitivity to -30 dBmV and the input attenuator to 0 dB. Set the following levels at the output of the unit-under-test:

CHANNEL	LEVEL
13	+47 dBmV
G	+47 dBmV
2	+47 dBmV

Three beats will occur as follows:

BEAT FREQUENCY	CHANNEL	f1	f2	
1	13-G	211.25 -	157.25 =	54.0 MHz
2	13-2	211.25 -	56.25 =	156.0 MHz
3	G+2	157.25 +	55.25 =	212.5 MHz

Turn off the channel carrier near the beat frequency of interest. Remove attenuation until the FSM meter moves up scale. Retune the FSM to find the frequency beat. The beat may be identified as the signal that disappears when either of the carriers is turned off. Adjust the attenuator until the meter returns to the reference level. The amount of attenuation removed equals the beat frequency attenuation.

The beat level should be at least 3 dB above the noise level for accurate measurements. If it is not, increase the output level of the unit-under-test. For any output level other than that desired, add the difference in dB to the beat attenuation.

All beat levels are referred to the nearest desired channels.

Appropriate filters may be employed at the input of the field strength meter to prevent second order beat frequency generation in the meter itself by eliminating one or both of the high level carriers.

MHW560

The RF Line

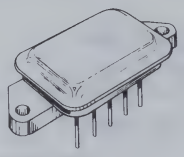
LOW NOISE WIDEBAND HYBRID AMPLIFIER

. . . designed for preamplifier applications in CATV line extender, bridger, and trunk amplifiers.

- Frequency Range – 40 to 300 MHz
- Power Gain – 14.5 dB (Min)
- Cross-Modulation Distortion –
  XM = -55 dB (Max) @ +45 dBmV, 21 Channels
- Noise Figure – 8.5 dB (Max)
- Hermetic Package

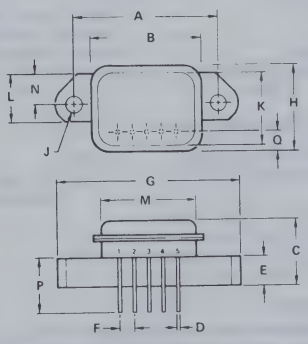
HYBRID WIDEBAND AMPLIFIER

40-300 MHz



ELECTRICAL SPECIFICATIONS (B+ = 24 Vdc)

Parameter	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	–	300	MHz
Power Gain	Gp	14.5	16	17	dB
Gain Flatness (Figure 3)	–	–	±0.2	±0.3	dB
Cross-Modulation Distortion (Figure 2) @ +45 dBmV, 21 Channel (Flat)	XM	–	–	-55	dB
Intermodulation Distortion (Second Order) @ +45 dBmV	IMD	–	–	-58	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	16	18	–	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	16	18	–	dB
Noise Figure	NF	–	8.0	8.5	dB
Power Dissipation (B+ = 24 Vdc)	P_D	–	–	5.0	W



STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.490	1.510	37.850	38.350
B	1.175	1.215	29.850	30.860
C	0.566	0.595	14.350	15.110
D	0.027	0.033	0.686	0.838
E	0.190	0.210	4.830	5.330
F	0.160 BSC		4.060 BSC	
G	1.850	1.890	46.990	48.010
H	0.920	0.960	23.370	24.380
J	0.150	0.170	3.810	4.320
K	0.710	0.740	18.030	18.800
L	0.490	0.510	12.450	12.950
M	0.970	1.005	24.640	25.530
N	0.455	0.485	11.560	12.320
P	0.360	0.400	9.140	10.160
Q	0.200 BSC		5.080 BSC	

CASE 270

FIGURE 1 – TYPICAL APPLICATION IN LINE EXTENDER AMPLIFIER

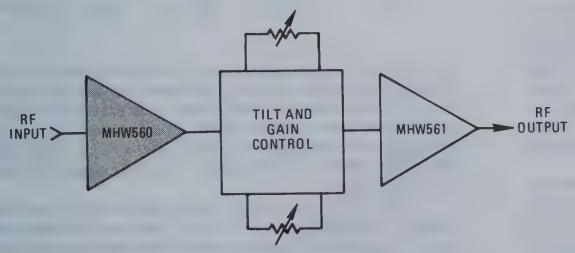


FIGURE 2 – CROSS MODULATION TEST METHOD

The following block diagram, is used for measuring cross modulation distortion:

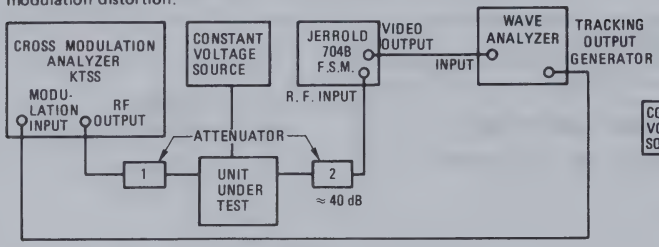
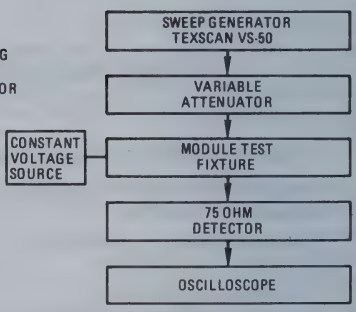


FIGURE 3 – GAIN FLATNESS TEST



The controls on the above test equipment shall be set as follows:

Field Strength Meter – 704B

1. Range Switch — Manual
2. Input Attenuator – both switched out

Wave Analyzer – GR 1900A

1. Mode	Tracking Generator
2. Bandwidth	10 Hz
3. Meter Speed	Medium (see operation information)
4. Frequency	15.750 kHz
5. Reading	Relative
6. Gain	Set for a full scale reading (see operation information)
7. Level	Maximum Clockwise
8. Tracking Generator Output	Connect to KTSS "modulation input"

Cross Modulation Analyzer – KTSS

1. Main power switch	ON
2. Modulation selector switch	External (see operation information)
3. Desired Channel Module Power Switch	ON
4. Desired Channel Module Modulation Switch	ON

Operation

With the equipment set-up as shown in Figure 2, switch the desired channel power switches ON. Set Attenuator 1 in combination with the channel module RF OUTPUT controls for desired levels from the unit-under-test. Set Attenuator 2 for approximately 40 dB attenuation. Caution should be taken to insure that the signal level into the field strength meter (FSM) is such that no distortion occurs in the meter itself. Adjust manual gain control on FSM such that the dc level out of the video output is 2.0 V dc when the meter is tuned to the unmodulated RF carrier to be tested. For these conditions the Jerrold 704B will give optimum cross modulation results. When measuring cross modulation on a particular channel, set a modulation reference for a full scale reading on the 3-volt wave analyzer scale. Adjust for a full scale reading by using the GAIN control on the wave analyzer.

After setting a modulation reference, switch the module modulation switch OFF. Increase the input sensitivity of the wave analyzer until the reading is near the mid-scale range on the wave analyzer meter. On lower levels, the meter speed switch can be set to SLOW, so that noise spikes will not interfere with the measurement. Cross modulation is the amount of attenuation removed from the meter range plus the meter scale difference from reference. Reduce the input sensitivity to what it formerly was and switch the module modulation switch back to ON. Repeat this process for each channel to be measured.

Procedure

1. Initially, connect the Variable Attenuator to the 75-Ohm Detector. Adjust the sweep generator to cover the desired frequency range and the variable attenuator to give a convenient reference trace on the oscilloscope.
2. Insert the module test fixture between the attenuator and detector. Add 15 dB of attenuation in the variable attenuator.
3. Determine the deviation from flatness and desired gain by removing or inserting attenuation with the variable attenuator and comparing the module response with the reference trace.
4. Alternate test methods, such as the use of a coaxial switcher may be employed.

INTERMODULATION DISTORTION TEST METHOD

Insert 70 dB of attenuation between the unit-under-test and the field strength meter. Set the field strength meter sensitivity to -30 dBmV and the input attenuator to 0 dB. Set the following levels at the output of the unit-under-test.:

CHANNEL	LEVEL
13	+45 dBmV
G	+45 dBmV
2	+45 dBmV

Three beats will occur as follows:

BEAT FREQUENCY	CHANNEL	f1	f2	
1	13-G	211.25	- 157.25 =	54.0 MHz
2	13-2	211.25	- 55.25 =	156.0 MHz
3	G+2	157.25	+ 55.25 =	212.5 MHz

Turn off the channel carrier near the beat frequency of interest. Remove attenuation until the FSM meter moves up scale. Retune the FSM to find the frequency beat. The beat may be identified as the signal that disappears when either of the carriers is turned off. Adjust the attenuator until the meter returns to the reference level. The amount of attenuation removed equals the beat frequency attenuation.

The beat level should be at least 6 dB above the noise level for accurate measurements. If it is not, increase the output level of the unit-under-test. For any output level other than that desired, add the difference in dB to the beat attenuation.

All beat levels are referred to the nearest desired channels.

Appropriate filters may be employed at the input of the field strength meter to prevent second order beat frequency generation in the meter itself by eliminating one or both of the high level carriers.

MHW561

The RF Line

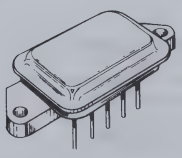
HYBRID WIDEBAND AMPLIFIER

. . . designed for use as an output stage in CATV line extender amplifiers

- Frequency Range – 40-300 MHz
- Power Gain – 14 dB (Min)
- Cross Modulation Distortion – XM = -57 dB (Max) @ +47 dBmV, 21 Channels
- Hermetic Package

HYBRID WIDEBAND AMPLIFIER

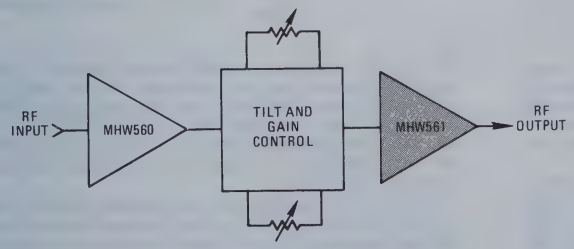
40-300 MHz

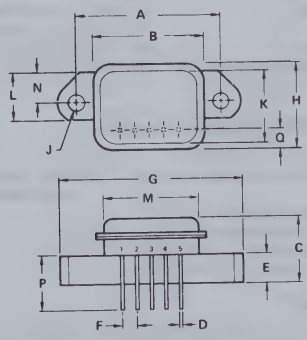


ELECTRICAL SPECIFICATIONS (B+ = 24 Vdc)

Parameter	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	–	300	MHz
Power Gain	Gp	14	15	16	dB
Gain Flatness (Figure 3)	–	–	±0.2	±0.3	dB
Cross-Modulation Distortion (Figure 2) @ +47 dBmV, 21 Channel (Flat)	XM	–	–	-57	dB
Intermodulation Distortion (Second Order) @+47 dBmV	IMD	–	–	-69	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	16	18	–	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	16	18	–	dB
Noise Figure	NF	–	10	12	dB
Power Dissipation (B+ = 24 Vdc)	P_D	–	–	6.0	W

FIGURE 1 – TYPICAL APPLICATION IN LINE EXTENDER AMPLIFIER





STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	1.490	1.510	37.850	38.350
B	1.175	1.215	29.850	30.860
C	0.566	0.595	14.350	15.110
D	0.027	0.033	0.686	0.838
E	0.190	0.210	4.830	5.330
F	0.160 BSC		4.060 BSC	
G	1.850	1.890	46.990	48.010
H	0.920	0.960	23.370	24.380
J	0.150	0.170	3.810	4.320
K	0.710	0.740	18.030	18.800
L	0.490	0.510	12.450	12.950
M	0.970	1.005	24.640	25.530
N	0.455	0.485	11.560	12.320
P	0.360	0.400	9.140	10.160
Q	0.200 BSC		5.080 BSC	

CASE 270

FIGURE 2 – CROSS MODULATION TEST METHOD

The following block diagram, is used for measuring cross modulation distortion:

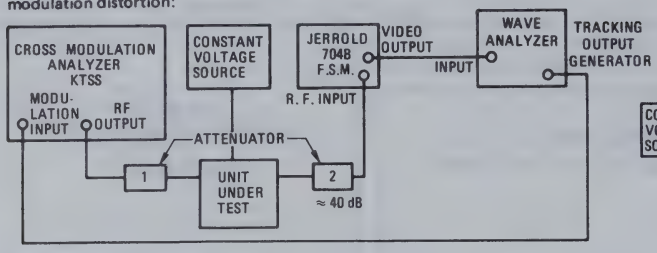
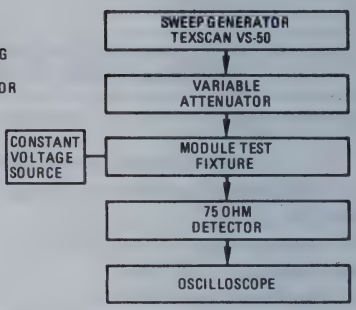


FIGURE 3 – GAIN FLATNESS TEST



The controls on the above test equipment shall be set as follows:

Field Strength Meter – 704B

1. Range Switch — Manual
2. Input Attenuator – both switched out

Wave Analyzer – GR 1900A

1. Mode — Tracking Generator
2. Bandwidth — 10 Hz
3. Meter Speed — Medium (see operation information)
4. Frequency — 15.750 kHz
5. Reading — Relative
6. Gain — Set for a full scale reading (see operation information)
7. Level — Maximum Clockwise
8. Tracking Generator Output — Connect to KTSS "modulation input"

Cross Modulation Analyzer – KTSS

1. Main power switch — ON
2. Modulation selector switch — External (see operation information)
3. Desired Channel Module Power Switch — ON
4. Desired Channel Module Modulation Switch — ON

Operation

With the equipment set-up as shown in Figure 2, switch the desired channel power switches ON. Set Attenuator 1 in combination with the channel module RF OUTPUT controls for desired levels from the unit-under-test. Set Attenuator 2 for approximately 40 dB attenuation. Caution should be taken to insure that the signal level into the field strength meter (FSM) is such that no distortion occurs in the meter itself. Adjust manual gain control on FSM such that the dc level out of the video output is 2.0 V dc when the meter is tuned to the unmodulated RF carrier to be tested. For these conditions the Jerrold 704B will give optimum cross modulation results. When measuring cross modulation on a particular channel, set a modulation reference for a full scale reading on the 3-volt wave analyzer scale. Adjust for a full scale reading by using the GAIN control on the wave analyzer.

After setting a modulation reference, switch the module modulation switch OFF. Increase the input sensitivity of the wave analyzer until the reading is near the mid-scale range on the wave analyzer meter. On lower levels, the meter speed switch can be set to SLOW, so that noise spikes will not interfere with the measurement. Cross modulation is the amount of attenuation removed from the meter range plus the meter scale difference from reference. Reduce the input sensitivity to what it formerly was and switch the module modulation switch back to ON. Repeat this process for each channel to be measured.

Procedure

1. Initially, connect the Variable Attenuator to the 75-Ohm Detector. Adjust the sweep generator to cover the desired frequency range and the variable attenuator to give a convenient reference trace on the oscilloscope.
2. Insert the module test fixture between the attenuator and detector. Add 15 dB of attenuation in the variable attenuator.
3. Determine the deviation from flatness and desired gain by removing or inserting attenuation with the variable attenuator and comparing the module response with the reference trace.
4. Alternate test methods, such as the use of a coaxial switcher may be employed.

INTERMODULATION DISTORTION TEST METHOD

Insert 70 dB of attenuation between the unit-under-test and the field strength meter. Set the field strength meter sensitivity to -30 dBmV and the input attenuator to 0 dB. Set the following levels at the output of the unit-under-test.:

CHANNEL	LEVEL
13	+47 dBmV
G	+47 dBmV
2	+47 dBmV

Three beats will occur as follows:

BEAT FREQUENCY	CHANNEL	f1	f2	
1	13-G	211.25	- 157.25 =	54.0 MHz
2	13-2	211.25	- 55.25 =	156.0 MHz
3	G+2	157.25	+ 55.25 =	212.5 MHz

Turn off the channel carrier near the beat frequency of interest. Remove attenuation until the FSM meter moves up scale. Retune the FSM to find the frequency beat. The beat may be identified as the signal that disappears when either of the carriers is turned off. Adjust the attenuator until the meter returns to the reference level. The amount of attenuation removed equals the beat frequency attenuation.

The beat level should be at least 6 dB above the noise level for accurate measurements. If it is not, increase the output level of the unit-under-test. For any output level other than that desired, add the difference in dB to the beat attenuation.

All beat levels are referred to the nearest desired channels.

Appropriate filters may be employed at the input of the field strength meter to prevent second order beat frequency generation in the meter itself by eliminating one or both of the high level carriers.

MHW562

The RF Line

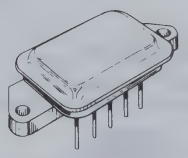
HYBRID WIDEBAND AMPLIFIER

. . . designed for use as an output stage in CATV bridger and trunk line amplifiers.

- Push-Pull Circuit Design
- Frequency Range – 40-300 MHz
- Power Gain – 14 dB (Min)
- Cross Modulation Distortion – XM = -60 dB (Max) @ +50 dBmV, 21 Channels
- Hermetic Package

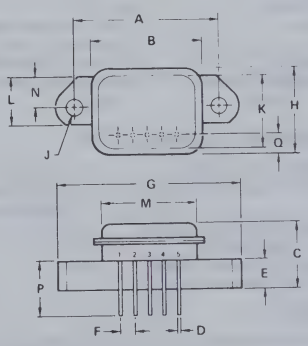
HYBRID WIDEBAND AMPLIFIER

40-300 MHz



ELECTRICAL SPECIFICATIONS (B+ = 24 Vdc)

Parameter	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	–	300	MHz
Power Gain	Gp	14	15	16	dB
Gain (Flatness)	–	–	±0.1	±0.25	dB
Cross-Modulation Distortion (Figure 3) @ +50 dBmV, 21 Channel (Flat)	XM	–	–	-60	dB
Intermodulation Distortion (Second Order) @ +50 dBmV	IMD	–	–	-69	dB
Input Return Loss (Figure 2) (Z_O = 75 Ohms)	Z_{in}	16	18	–	dB
Output Return Loss (Z_O = 75 Ohms)	Z_{out}	16	18	–	dB
Noise Figure	NF	–	–	10	dB
Power Dissipation (B+ = 24 Vdc)	P_D	–	–	6.0	W



STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	1.490	1.510	37.850	38.350
B	1.175	1.215	29.850	30.860
C	0.566	0.595	14.350	15.110
D	0.027	0.033	0.686	0.838
E	0.190	0.210	4.830	5.330
F	0.160 BSC		4.060 BSC	
G	1.850	1.890	46.990	48.010
H	0.920	0.960	23.370	24.380
J	0.150	0.170	3.810	4.320
K	0.710	0.740	18.030	18.800
L	0.490	0.510	12.450	12.950
M	0.970	1.005	24.640	25.530
N	0.455	0.485	11.560	12.320
P	0.360	0.400	9.140	10.160
Q	0.200 BSC		5.080 BSC	

CASE 270

FIGURE 1 – TYPICAL APPLICATION IN TRUNK LINE AMPLIFIER

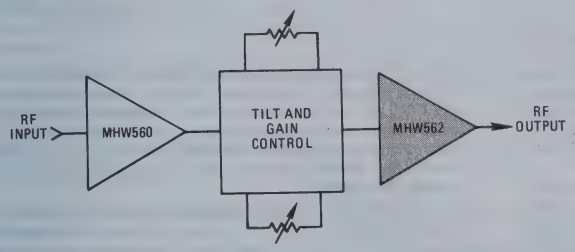


FIGURE 2 – CROSS MODULATION TEST METHOD

The following block diagram, is used for measuring cross modulation distortion:

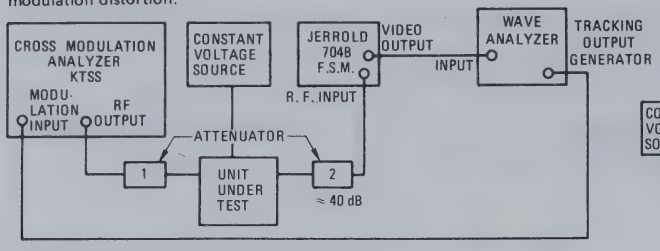
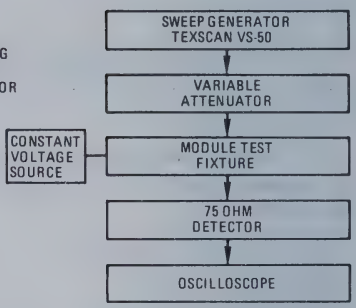


FIGURE 3 – GAIN FLATNESS TEST



The controls on the above test equipment shall be set as follows:

Field Strength Meter – 704B

1. Range Switch — Manual
2. Input Attenuator — both switched out

Wave Analyzer – GR 1900A

1. Mode — Tracking Generator
2. Bandwidth — 10 Hz
3. Meter Speed — Medium (see operation information)
4. Frequency — 15.750 kHz
5. Reading — Relative
6. Gain — Set for a full scale reading (see operation information)
7. Level — Maximum Clockwise
8. Tracking Generator Output — Connect to KTSS "modulation input"

Cross Modulation Analyzer – KTSS

1. Main power switch — ON
2. Modulation selector switch — External (see operation information)
3. Desired Channel Module Power Switch — ON
4. Desired Channel Module Modulation Switch — ON

Operation

With the equipment set-up as shown in Figure 2, switch the desired channel power switches ON. Set Attenuator 1 in combination with the channel module RF OUTPUT controls for desired levels from the unit-under-test. Set Attenuator 2 for approximately 40 dB attenuation. Caution should be taken to insure that the signal level into the field strength meter (FSM) is such that no distortion occurs in the meter itself. Adjust manual gain control on FSM such that the dc level out of the video output is 2.0 V dc when the meter is tuned to the unmodulated RF carrier to be tested. For these conditions the Jerrold 704B will give optimum cross modulation results. When measuring cross modulation on a particular channel, set a modulation reference for a full scale reading on the 3-volt wave analyzer scale. Adjust for a full scale reading by using the GAIN control on the wave analyzer.

After setting a modulation reference, switch the module modulation switch OFF. Increase the input sensitivity of the wave analyzer until the reading is near the mid-scale range on the wave analyzer meter. On lower levels, the meter speed switch can be set to SLOW, so that noise spikes will not interfere with the measurement. Cross modulation is the amount of attenuation removed from the meter range plus the meter scale difference from reference. Reduce the input sensitivity to what it formerly was and switch the module modulation switch back to ON. Repeat this process for each channel to be measured.

Procedure

1. Initially, connect the Variable Attenuator to the 75-Ohm Detector. Adjust the sweep generator to cover the desired frequency range and the variable attenuator to give a convenient reference trace on the oscilloscope.
2. Insert the module test fixture between the attenuator and detector. Add 15 dB of attenuation in the variable attenuator.
3. Determine the deviation from flatness and desired gain by removing or inserting attenuation with the variable attenuator and comparing the module response with the reference trace.
4. Alternate test methods, such as the use of a coaxial switcher may be employed.

INTERMODULATION DISTORTION TEST METHOD

Insert 70 dB of attenuation between the unit-under-test and the field strength meter. Set the field strength meter sensitivity to -30 dBmV and the input attenuator to 0 dB. Set the following levels at the output of the unit-under-test.:

CHANNEL	LEVEL
13	+50 dBmV
G	+50 dBmV
2	+50 dBmV

Three beats will occur as follows:

BEAT FREQUENCY	CHANNEL	f1	f2	
1	13-G	211.25	- 157.25 =	54.0 MHz
2	13-2	211.25	- 55.25 =	156.0 MHz
3	G+2	157.25	+ 55.25 =	212.5 MHz

Turn off the channel carrier near the beat frequency of interest. Remove attenuation until the FSM meter moves up scale. Retune the FSM to find the frequency beat. The beat may be identified as the signal that disappears when either of the carriers is turned off. Adjust the attenuator until the meter returns to the reference level. The amount of attenuation removed equals the beat frequency attenuation.

The beat level should be at least 6 dB above the noise level for accurate measurements. If it is not, increase the output level of the unit-under-test. For any output level other than that desired, add the difference in dB to the beat attenuation.

All beat levels are referred to the nearest desired channels.

Appropriate filters may be employed at the input of the field strength meter to prevent second order beat frequency generation in the meter itself by eliminating one or both of the high level carriers.

MHW709

The RF Line

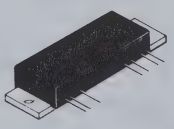
UHF POWER MODULE

. . . designed for Land Mobile Communications equipment in the UHF band.

- Frequency Range — 400 to 470 MHz
- Power Gain — Gp = 18.8 dB (Min)
- Output Power — P_{out} = 7.5 W (Min)

UHF POWER MODULE

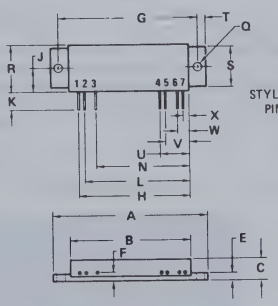
7.5 W, 12.5 V
400-470 MHz



ELECTRICAL CHARACTERISTICS (V_s and V_{sc} set at 12.5 Vdc unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Frequency Range (1)	—	400	470	MHz
Output Power (P_{in} = 100 mW)	P_{out}	7.5	—	Watts
Power Gain	Gp	18.8	—	dB
Efficiency (P_{out} = 7.5 W)	η	35	—	%
Harmonics (P_{out} = 7.5 W, Reference)	—	—	-40	dB
Input Impedance (P_{out} = 7.5 W, 50 Ohm Reference)	Z_{in}	—	2:1	VSWR
Power Degradation (P_{out} = 7.5 W, T_C = 25°C) (T_C = 0°C to 60°C)	—	—	0.3	dB
Power Degradation (P_{out} = 7.5 W, T_C = 25°C) (T_C = 0°C to 80°C)	—	—	0.7	dB
Load Mismatch (VSWR = ∞, V_s = 15 Vdc, P_{out} = 7.5 W)	—	No degradation in P_{out}		
Stability (P_{in} = 30 to 150 mW, Load Mismatch 2:1 50 Ohm Reference, V_s = 8.0 to 16 Vdc, V_{sc} adjusted for P_{out} = 5.0 to 12 W)	—	All spurious outputs more than 70 dB below desired signal.		

(1) Frequency Range is covered in two bands:
MHW709-1 400-440 MHz
MHW709-2 440-470 MHz



STYLE 1:
PIN 1. RF OUTPUT
2. GROUND
3. D.C. TERM
4. GROUND
5. D.C. GAIN
6. GROUND
7. RF INPUT

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	67.18	67.44	2.645	2.655
B	52.32	52.83	2.060	2.080
C	8.64	9.65	0.340	0.380
E	2.54	3.05	0.100	0.120
F	2.16	2.41	0.085	0.095
G	60.96	61.21	2.400	2.410
H	47.88	48.64	1.885	1.915
J	10.67	11.18	0.420	0.440
K	5.84	7.62	0.230	0.300
L	45.34	46.10	1.785	1.815
N	40.26	41.02	1.585	1.615
Q	3.45	3.71	0.156	0.146
R	20.57	21.08	0.810	0.830
S	17.15	17.40	0.675	0.685
T	2.92	3.18	0.115	0.125
U	12.32	13.08	0.485	0.515
V	9.78	10.54	0.385	0.415
W	4.70	5.46	0.185	0.215
X	2.16	2.92	0.085	0.115

CASE 700-01

TYPICAL PERFORMANCE CURVES
(MHW709-2)

FIGURE 1 – INPUT POWER, EFFICIENCY, and VSWR versus FREQUENCY

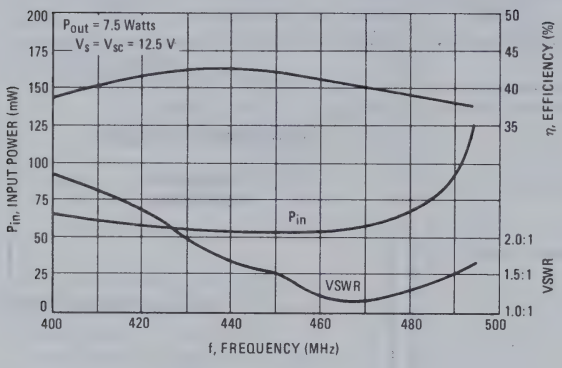


FIGURE 2 – OUTPUT POWER VERSUS INPUT POWER

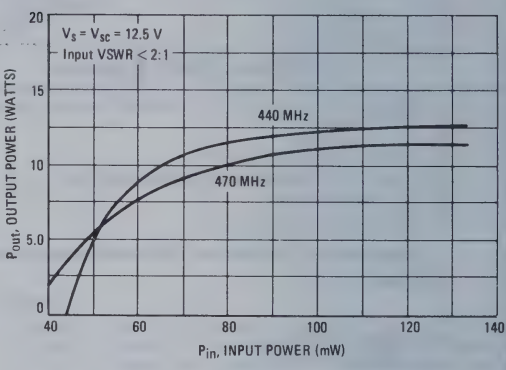


FIGURE 3 – OUTPUT POWER versus VOLTAGE

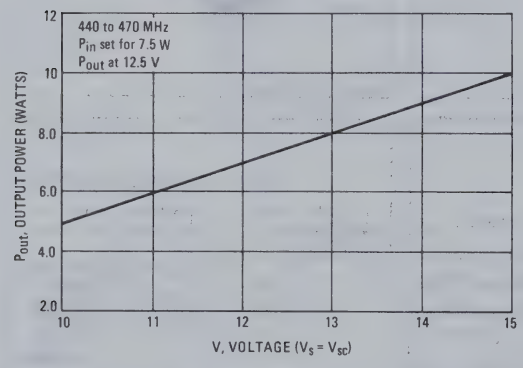


FIGURE 4 – OUTPUT POWER versus GAIN CONTROL VOLTAGE

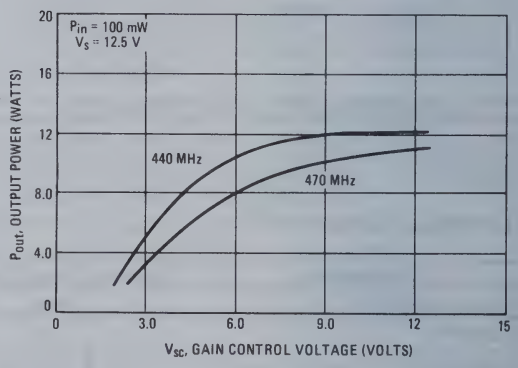
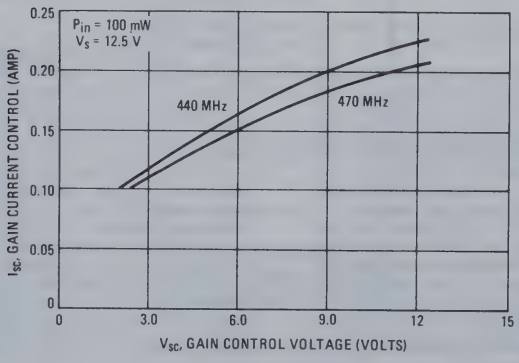


FIGURE 5 – GAIN CONTROL CURRENT versus VOLTAGE



UHF Power Module Test Information

FIGURE 1 – TEST CIRCUIT

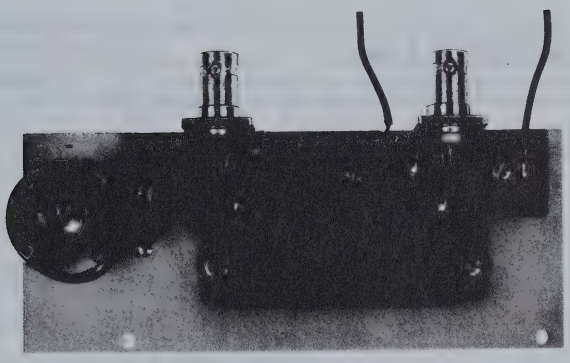


FIGURE 2 – UHF POWER MODULE TEST FIXTURE
PRINTED CIRCUIT BOARD

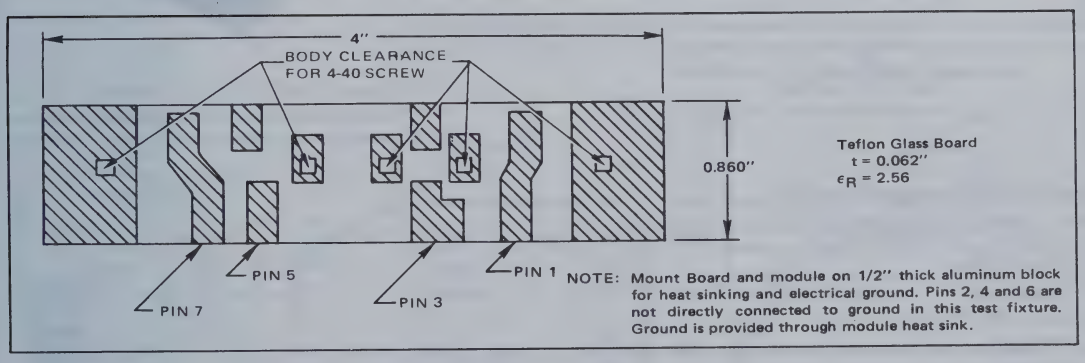
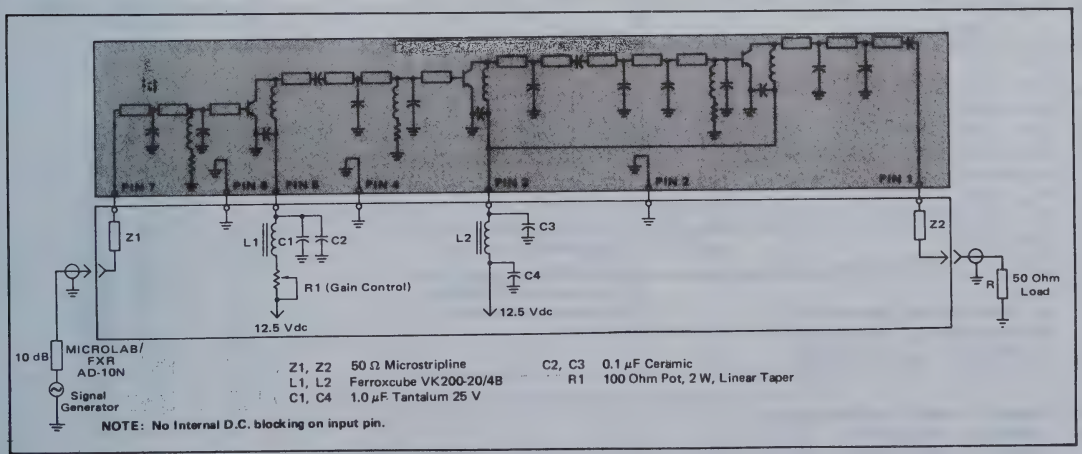


FIGURE 3 – UHF POWER MODULE TEST SETUP



MHW710

The RF Line

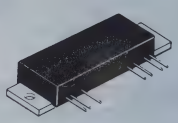
UHF POWER MODULE

. . . designed for Land Mobile Communications equipment in the UHF band.

- Frequency Range – 400 to 470 MHz
- Power Gain – G_p = 19.4 dB (Min)
- Output Power – P_{out} = 13 W (Min)

UHF POWER MODULE

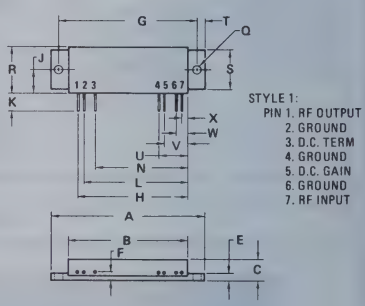
13 W, 12.5 V
400-470 MHz



ELECTRICAL CHARACTERISTICS (V_s and V_{sc} set at 12.5 Vdc unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Frequency Range (1)	—	400	470	MHz
Output Power (P_{in} = 150 mW)	P_{out}	13	—	Watts
Power Gain	G_p	19.4	—	dB
Efficiency (P_{out} = 13 W)	η	35	—	%
Harmonics (P_{out} = 13 W, Reference)	—	—	-40	dB
Input Impedance (P_{out} = 13 W, 50 Ohm Reference)	Z_{in}	—	2:1	VSWR
Power Degradation (P_{out} = 13 W, T_C = 25°C) (T_C = 0°C to 60°C)	—	—	0.3	dB
Power Degradation (P_{out} = 13 W, T_C = 25°C) (T_C = 0°C to 80°C)	—	—	0.7	dB
Load Mismatch (VSWR = ∞, V_s = 15 Vdc, P_{out} = 13 W)	—	No degradation in P_{out}		
Stability (P_{in} = 50 to 200 mW, Load Mismatch 2:1 50 ohm reference, V_s = 8.0 to 16 Vdc, V_{sc} adjusted for P_{out} = 5.0 to 16 W)	—	All spurious outputs more than 70 dB below desired signal.		

(1) Frequency Range is covered in two bands:
MHW710-1 400-440 MHz
MHW710-2 440-470 MHz



STYLE 1:
PIN 1. RF OUTPUT
2. GROUND
3. D.C. TERM
4. GROUND
5. D.C. GAIN
6. GROUND
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DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	67.18	67.44	2.645	2.655
B	52.32	52.83	2.060	2.080
C	8.64	9.65	0.340	0.380
E	2.54	3.05	0.100	0.120
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L	45.34	46.10	1.785	1.815
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Q	3.45	3.71	0.156	0.146
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W	4.70	5.46	0.185	0.215
X	2.16	2.92	0.085	0.115

CASE 700-01

TYPICAL PERFORMANCE CURVES
(MHW710-2)

FIGURE 1 – INPUT POWER, EFFICIENCY AND VSWR versus FREQUENCY

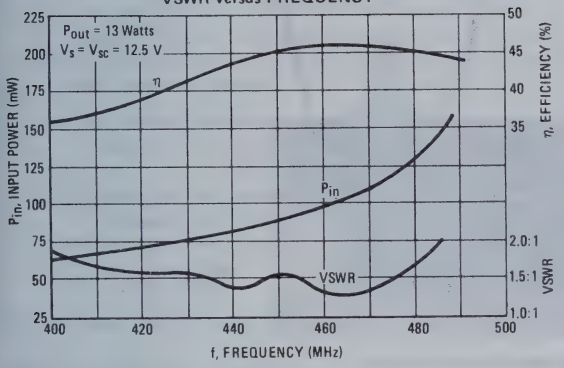


FIGURE 2 – OUTPUT POWER versus INPUT POWER

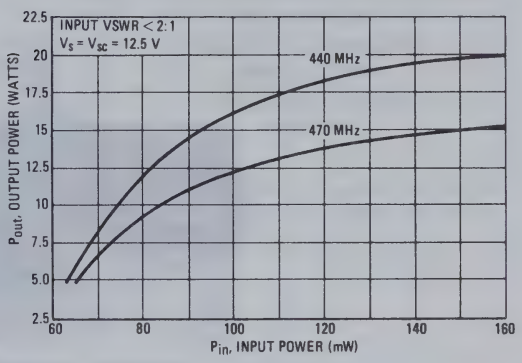


FIGURE 3 – OUTPUT POWER versus VOLTAGE

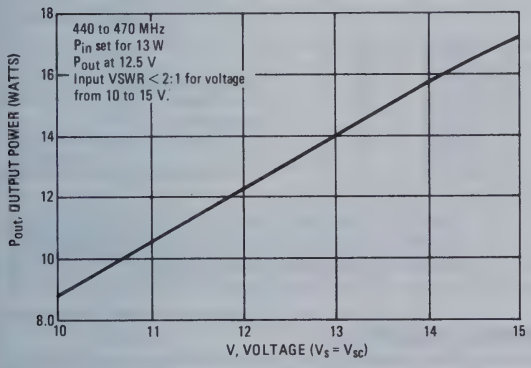


FIGURE 4 – OUTPUT POWER versus GAIN CONTROL VOLTAGE

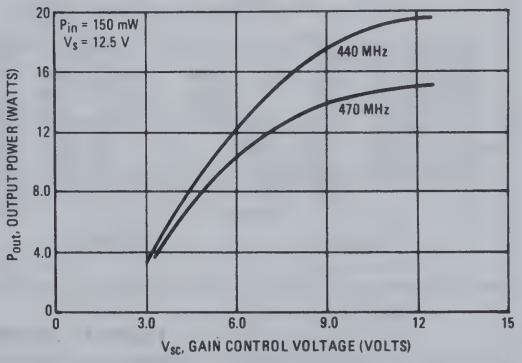
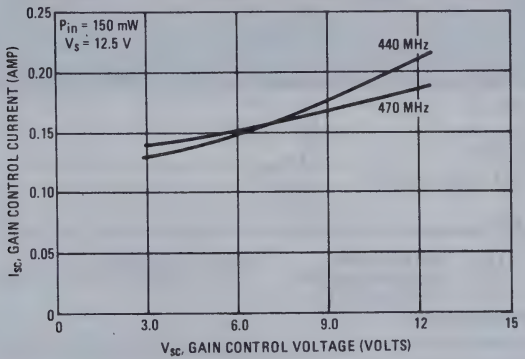


FIGURE 5 – GAIN CONTROL CURRENT versus VOLTAGE



UHF Power Module Test Information

FIGURE 1 – TEST CIRCUIT

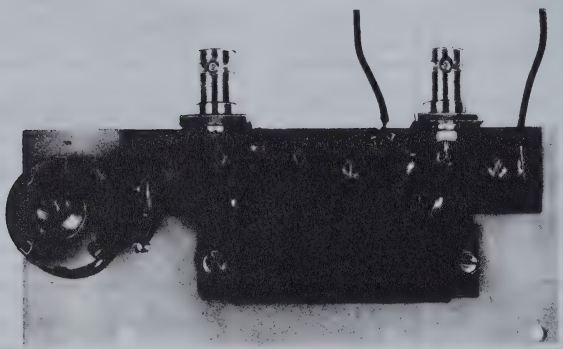


FIGURE 2 – UHF POWER MODULE TEST FIXTURE
PRINTED CIRCUIT BOARD

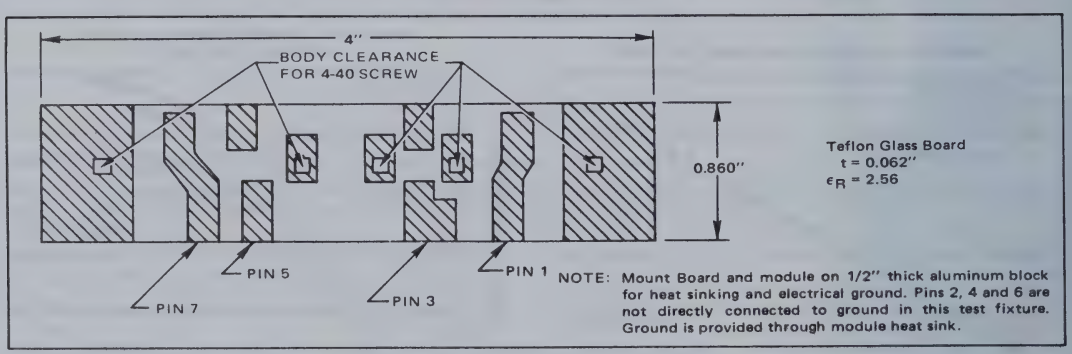
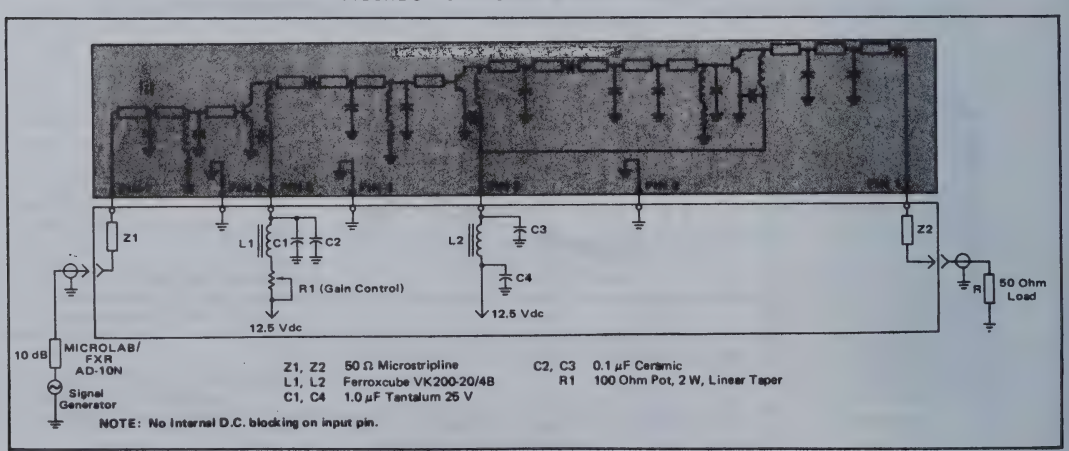


FIGURE 3 – UHF POWER MODULE TEST SETUP



MJ105 (SILICON)
BU105

HORIZONTAL DEFLECTION SILICON TRANSISTORS

. . . designed for use in line operated black and white (19 and 20 inch 110° deflection circuits) or color (11 and 14 inch 90° deflection circuits) television receivers.

- High Collector-Emitter Voltage –
  V_{CER}(Peak) = 1400 Vdc – MJ105
  = 1500 Vdc – BU105
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 5.0 Vdc (Max) @ I_C = 2.5 Adc
- Fall Time @ I_C = 2.0 Adc –
  t_f = 0.5 μs (Typ)
  = 1.0 μs (Max)

2.5 AMPERE
POWER TRANSISTORS
NPN SILICON
1400, 1500 VOLTS
10 WATTS



MAXIMUM RATINGS

Rating	Symbol	MJ105	BU105	Unit
Collector-Emitter Voltage	V_{CEO}	750		Vdc
Collector-Emitter Voltage – Continuous (R_{BE} = 100 Ω)	V_{CER}	750	750	V
Peak		1400	1500	
Collector-Base Voltage – Continuous	V_{CB}	750	750	V
Peak		1400	1500	
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	2.5		Adc
Base Current – Positive	I_B	2.5		Adc
Negative		1.5		
Total Device Dissipation @ T_C = 90°C	P_D	10		Watts
Derate above 90°C		0.4		W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +115		°C

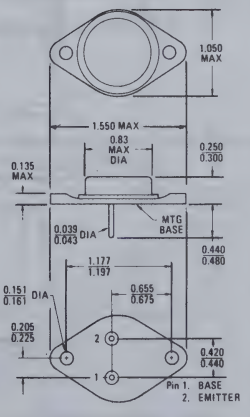
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$	750	–	–	Vdc
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 1400 Vdc, V_{BE} = 0)	MJ105		–	–	1.0	
(V_{CE} = 1500 Vdc, V_{BE} = 0)	BU105		–	–	1.0	
Emitter-Base Voltage (I_E = 100 mAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
ON CHARACTERISTICS						
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 1.5 Adc)		$V_{CE(sat)}$	–	–	5.0	Vdc
Base-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 1.5 Adc)		$V_{BE(sat)}$	–	–	1.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (2) (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)		f_T	–	7.5	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	65	–	pF
SWITCHING CHARACTERISTICS (Figure 1 and text)						
Fall Time (I_C = 2.0 Adc, I_{B1} = 1.5 Adc, L_B = 12 μH, R_B = 2.5, Non-optimum values to comply with BU105 specification)		t_f	–	0.5	1.0	μs

(1) Pulse Test: Pulse Width 300 μs, Duty Cycle ≈ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$



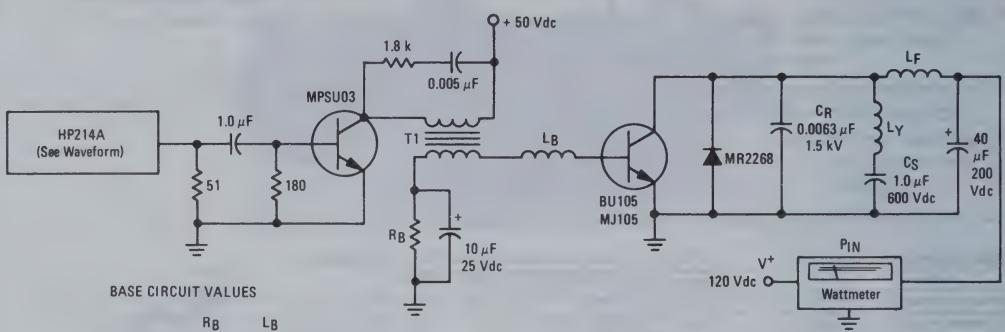
All JEDEC dimensions and notes apply
Collector connected to case

CASE 11
TO-3

CIRCUIT OPTIMIZATION

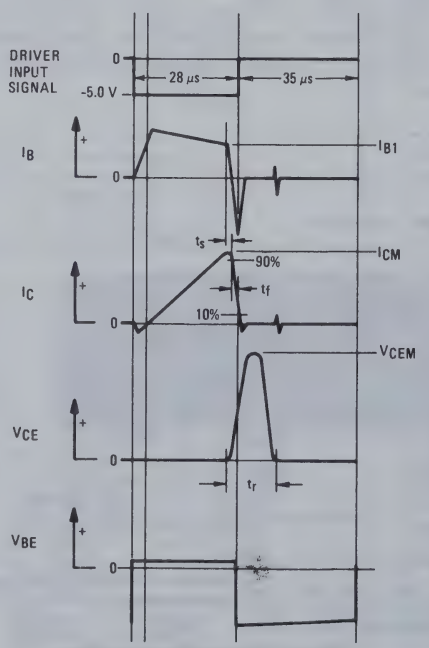
Test/application circuit and operating waveforms for BU105/MJ105 are shown in Figure 1. It may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, the circuit was designed with operating efficiency in mind, so that it could be used to evaluate devices by one simple criterion, supply power input. Excessive power input can be caused by a variety of problems, but it is the dissipation itself that is of fundamental importance. Once the transistor operating point has been established, fixed circuit values may be selected for the test fixture. Factory testing may then be made with one meter reading, without adjustment of the test apparatus.

FIGURE 1 – TEST CIRCUIT AND WAVEFORMS



BASE CIRCUIT VALUES

	R_B	L_B
Switching Test	2.5	12.0
Optimum	7.0	15.0



FUNDAMENTAL WAVEFORMS OF A SIMPLIFIED HORIZONTAL DEFLECTION CIRCUIT

DESCRIPTION OF SPECIAL COMPONENTS

DUMMY YOKE INDUCTOR (L_Y)

2.0 mH, 52.5 turns, #16 AWG enamel wire 15 turns per layer, 3.5 layers on 1.375 inch diameter bobbin, enclosed in a Ferroxcube, cup core K535221-B2A, with a 0.687 inch diameter core, with 0.003 inch core gap. Use a nylon bolt and nut to hold cup halves together.

DUMMY HIGH VOLTAGE AND HORIZONTAL SCAN TRANSFORMER (L_F)

5.5 mH, 121 turns, #20 AWG enamel wire 33 turns per layer, 3.6 layers 1 mil mylar insulation between layers wound on 1 leg of Allen Bradley 0.5 inch square Ferrite "U" core (2) WO3 material with 0.007 inch gap in each leg. Core halves held together with plastic.

DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance - 39 mH, Secondary Inductance - 0.22 mH, Leakage inductance with primary shorted - 2.0 μH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

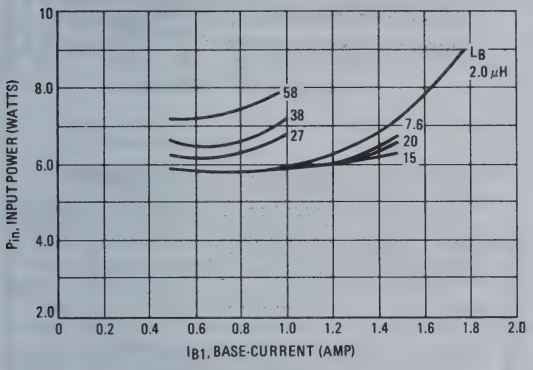
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 1, is one of voltage capability. The flyback voltage to which the device will be subjected is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, shown in Figure 1, will usually be about 8 times the value of V^+, but may be varied somewhat by adjusting retrace time and flyback tuning. For this reason these high voltage devices are particularly useful in cost conscious solid state receivers, as they permit the use of an off-the-line half wave power supply.

COLLECTOR CIRCUIT VALUES

The power supply used in the circuit of Figure 1, was chosen to produce a 1000 volt collector pulse on the transistor, a conservative value, recommended for unregulated applications. The values of yoke (L_Y), flyback primary (L_F), retrace capacitor (C_R), and "S" shaping capacitor (C_S) shown, will result in a peak collector current of about 2.0 A. This is sufficient to deflect (and provide high voltage for) large screen 110° black and white or small 90° color receivers. Peak collector currents to 2.5 A may be handled by the BU105/MJ105. Holding the supply constant for most efficient application, adjustment of amount of deflection may be made by raising or lowering L_Y and L_F. Remember that L_Y I_Y is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 2 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_C = 2.0 A PEAK



BASE CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or Uniwatt type will generally be needed. Once this is done, the turns ratio of the driver transformer can be picked to produce about 4 to 5 volts peak to peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low ac impedance for good turn-off of the output device. In Figure 2, the effects of varying L_B and I_{B1} on the total power input to the deflection circuit are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 2 is 15 μH. Remember that this is the sum of the actual leakage inductance of the transformer (secondary inductance with primary shorted) and an external L, if necessary. The best value of I_{B1} is 0.8 A achieved in the typical device by using R_B = 7 Ω, derived experimentally.

These are the choices recommended for the test fixture, when the transistor is used at I_{CM} = 2.0 A. For other values of I_{CM} the drive circuit components must be changed. Figure 3 shows the values of L_B and I_{B1} which should be used.

The value of R_B which will be required to produce the I_{B1} is also given, but of course, it is not an independent variable.

PERFORMANCE

Shown in Figures 4 and 5 are the results which will be typically obtained with the test circuit at various operating conditions.

FIGURE 3 – INTERRELATION OF R_B, L_B, AND I_{B1}

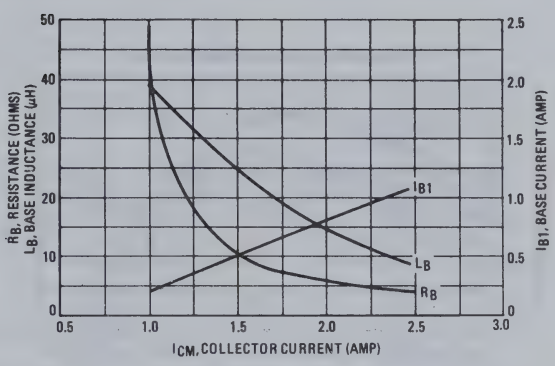


FIGURE 4 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

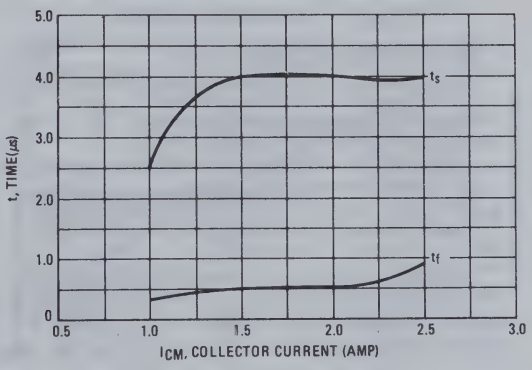
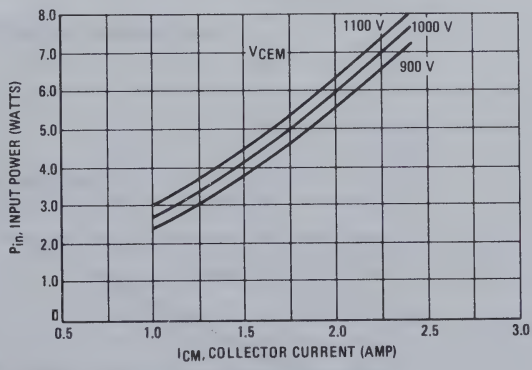


FIGURE 5 – P_{IN}, POWER DISSIPATION, WITH DEVIATIONS OF V_{CEM} AND I_{CM}



TYPICAL TRANSISTOR CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

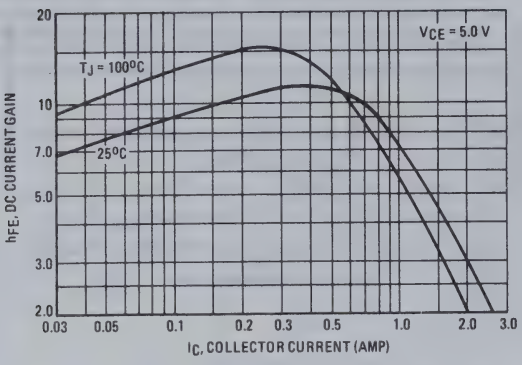


FIGURE 2 – "ON" VOLTAGES

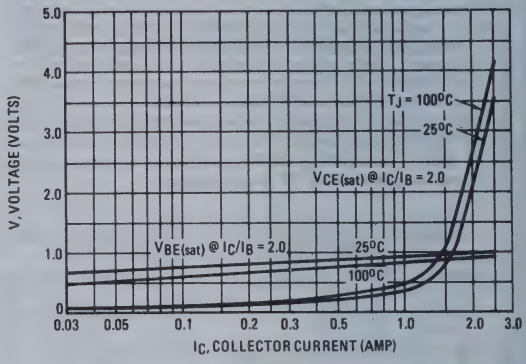


FIGURE 3 – SAFE OPERATING AREA

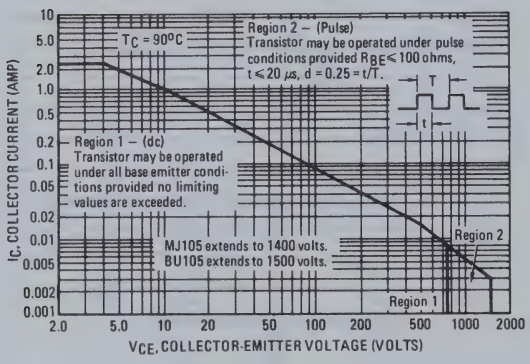
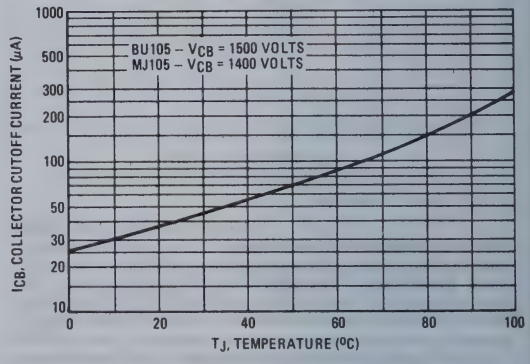
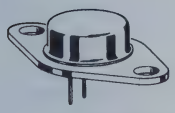


FIGURE 4 – COLLECTOR CUTOFF CURRENT



MJ400 (SILICON)



PIN 1. BASE
2. EMITTER

CASE 80
(TO-66)

Collector connected to case

High-voltage NPN silicon transistor designed for video output circuitry in color television receivers.

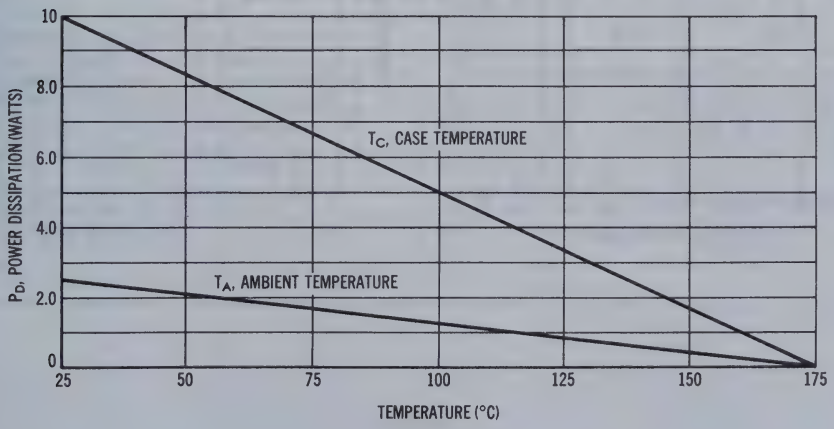
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Base Voltage	V_{CB}	350	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current-Continuous Peak	I_C	250 1000	mAdc
Base Current	I_B	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	2.5 0.0167	Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	6.67 0.067	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	15	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	60	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	325	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 325 Vdc, I_B = 0)	I_{CEO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	300	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)	f_T	15	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	10	pF
Small Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	25	—	—

(1) Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 2 — CURRENT GAIN CHARACTERISTICS

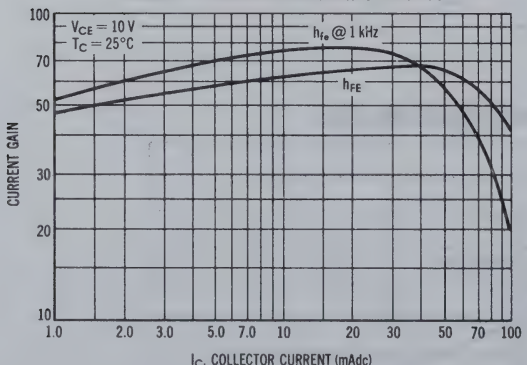
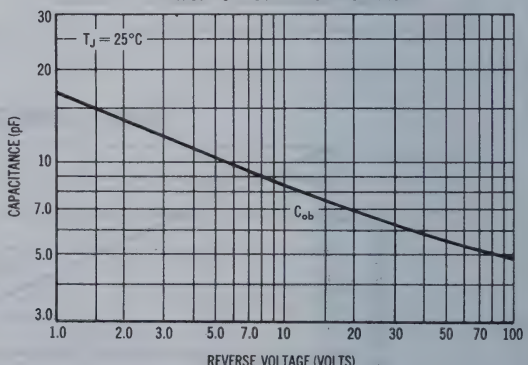


FIGURE 3 — OUTPUT CAPACITANCE



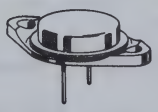
MJ410 (SILICON)
MJ411

HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . designed for medium to high voltage inverters, converters, regulators and switching circuits.

- High Collector-Emitter Voltage –
  V_{CEO} = 200 Volts – MJ410
  300 Volts – MJ411
- DC Current Gain Specified @ 1.0 and 2.5 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.8 Vdc @ I_C = 1.0 Adc

5 AMPERE
POWER TRANSISTORS
NPN SILICON
200–300 VOLTS
100 WATTS



MAXIMUM RATINGS

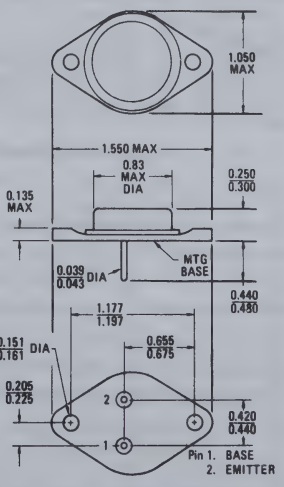
Rating	Symbol	MJ410	MJ411	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CB}	200	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	MJ410 MJ411	$V_{CEO(sus)}$	200 300	– –	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, I_B = 0) (V_{CE} = 300 Vdc, I_B = 0)	 MJ410 MJ411	I_{CEO}	 – –	 0.25 0.25	mAdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C) (V_{CE} = 300 Vdc, $V_{EB(off)}$ - 1.5 Vdc, T_C = 125°C)	MJ410 MJ411	I_{CEX}	– –	0.5 0.5	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	 30 10	 90 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.5	–	MHz

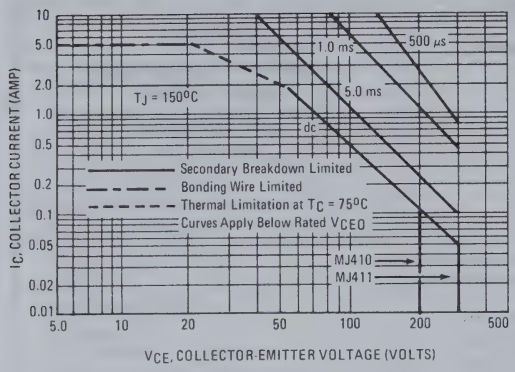


All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

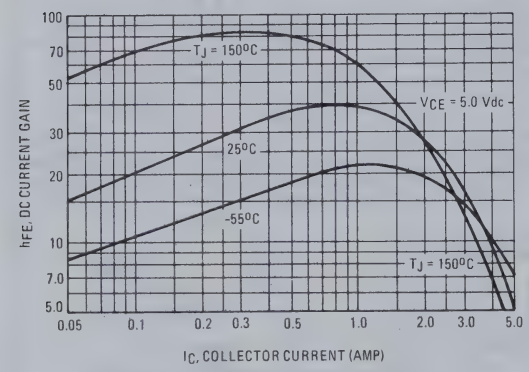


FIGURE 3 – "ON" VOLTAGES

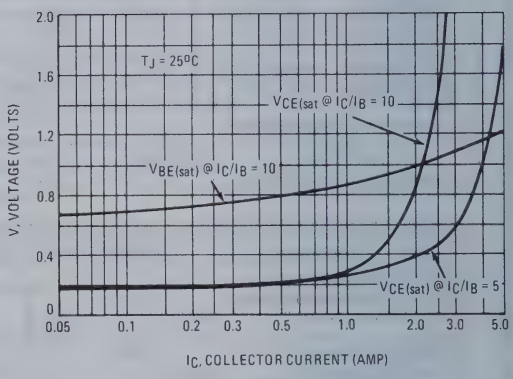


FIGURE 4 – SUSTAINING VOLTAGE TEST LOAD LINE

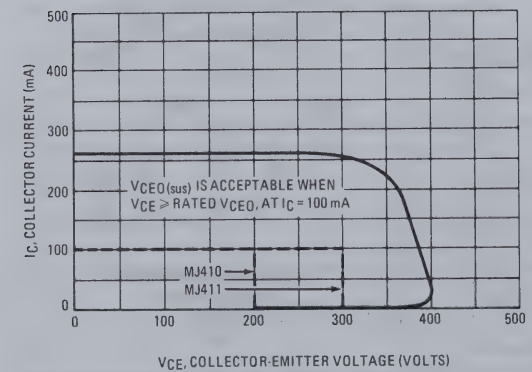
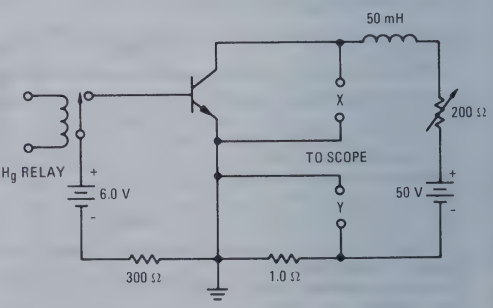


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ413 (SILICON)
MJ423
MJ431



CASE 11
(TO-3)

Collector connected to case

PIN 1. BASE
2. COLLECTOR

High-voltage NPN silicon transistors designed for medium-to-high-voltage inverters, converters, regulators and switching circuits.

MAXIMUM RATINGS

Rating	Symbol	MJ413	MJ423	MJ431	Unit
Collector-Emitter Voltage	V_{CEX}	400	400	400	Vdc
Collector-Base Voltage	V_{CB}	400	400	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	10	10	10	Adc
Base Current	I_B	2.0	2.0	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0			Watts W/°C
Operation Junction Temperature Range	T_J	-65 to +150			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$	325	—	Vdc
Collector Cutoff Current (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ413, MJ423 MJ431	I_{CEX}	— —	0.25 2.5	mAdc
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	MJ413, MJ423 MJ431		— —	0.5 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	MJ413, MJ423 MJ431	I_{EBO}	— —	5.0 2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	MJ413	h_{FE}	20	80	—
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			15	—	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	MJ423		30	90	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	MJ431		15	35	
(I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
Collector-Emitter Saturation Voltage (1) (I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413	$V_{CE(sat)}$	—	0.8	Vdc
(I_C = 1.0 Adc, I_B = 0.10 Adc)	MJ423		—	0.8	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	0.7	
Base-Emitter Saturation Voltage (1) (I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413	$V_{BE(sat)}$	—	1.25	Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ423		—	1.25	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10Vdc, f = 1.0 MHz)		f_T	2.5	—	MHz

(1) PW ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — ACTIVE-REGION SAFE-OPERATING AREA

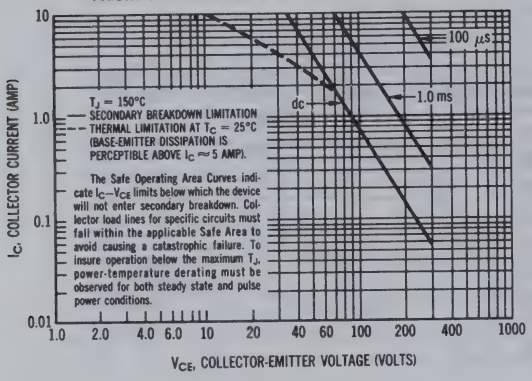


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE

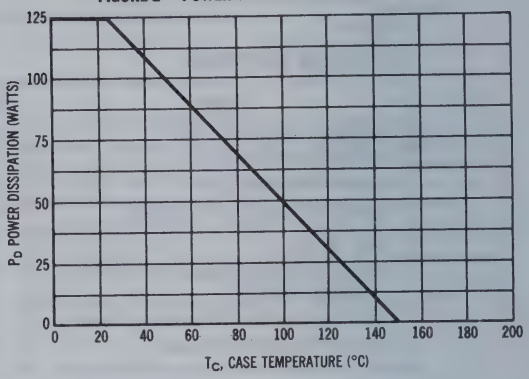


FIGURE 3 — SUSTAINING VOLTAGE TEST LOAD LINE

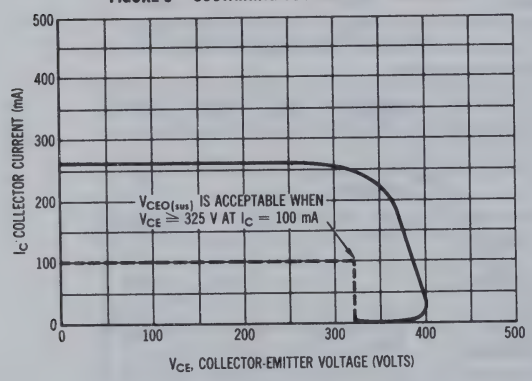


FIGURE 4 — SUSTAINING VOLTAGE TEST CIRCUIT

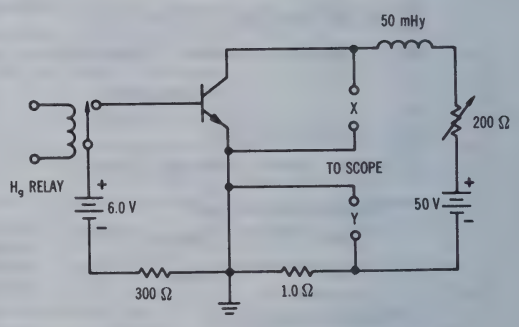


FIGURE 5 — CURRENT GAIN

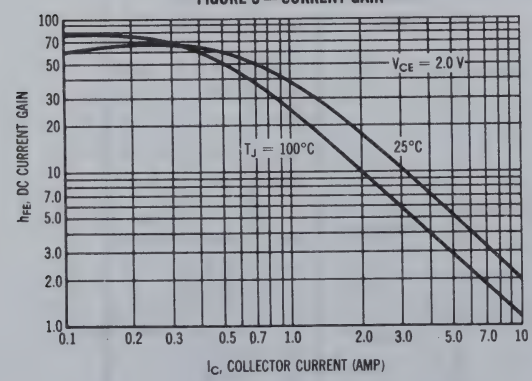
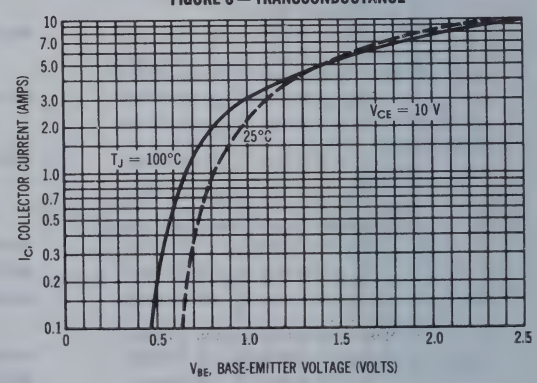


FIGURE 6 — TRANSCONDUCTANCE



MJ420 (SILICON)
MJ421

HIGH-VOLTAGE NPN SILICON TRANSISTORS

. . . designed for video output circuitry in transistorized television receivers

- High Voltages — V_{CEO} = 250 V and 325 V
- Low Feedback Capacitance — C_{re} = 12 pF (Max) @ 20 Vdc
- Recommended For Use To I_C = 30 mAdc

100 MILLIAMP
POWER TRANSISTORS
NPN SILICON

275-350 VOLTS
2.5 WATTS



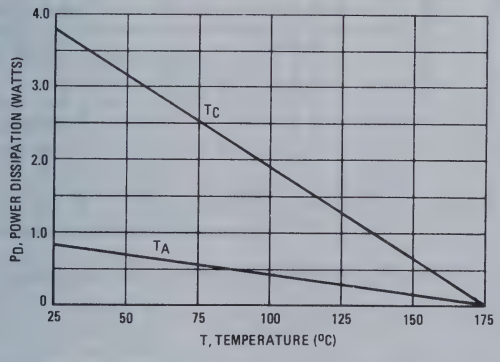
MAXIMUM RATING

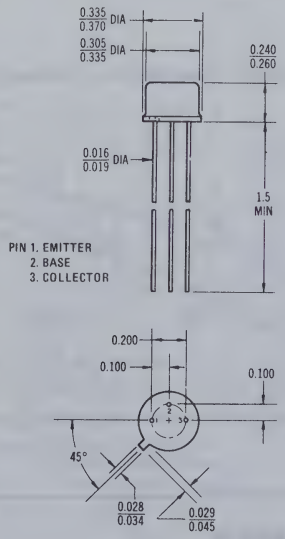
Rating	Symbol	MJ420	MJ421	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CB}	275	350	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous Peak	I_C	100 500		mAdc
Base Current	I_B	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 0.0053		Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	2.5 0.025		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	40	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	187	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





CASE 31(1)
TO-5
Collector connected to case.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	MJ420 MJ421	$V_{CEO(sus)}$	250 325	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	MJ420 MJ421	BV_{CBO}	275 350	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = rated voltage, I_B = 0)		I_{CEO}	–	1.0	mAdc
Collector Cutoff Current (V_{CB} = rated voltage, I_E = 0)		I_{CBO}	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 20 Vdc) (I_C = 10 mAdc, V_{CE} = 20 Vdc) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		h_{FE}	 15 25 25	 – – 250	–
Collector-Emitter Saturation Voltage (1) (I_C = 30 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	–	5.0	Vdc
Base-Emitter On Voltage (1) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 10 MHz)		f_T	15	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CE} = 20 Vdc, I_C = 0)		C_{re}	–	12	pF
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	12	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

(1) Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%

FIGURE 2 – CURRENT GAIN CHARACTERISTICS

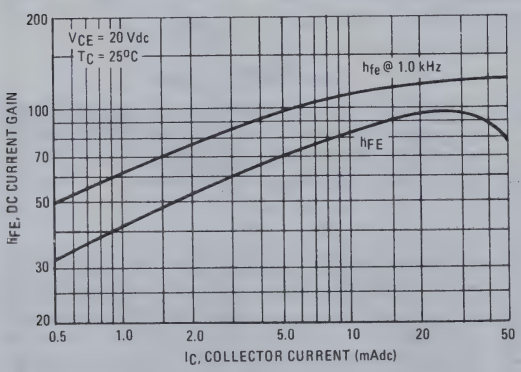
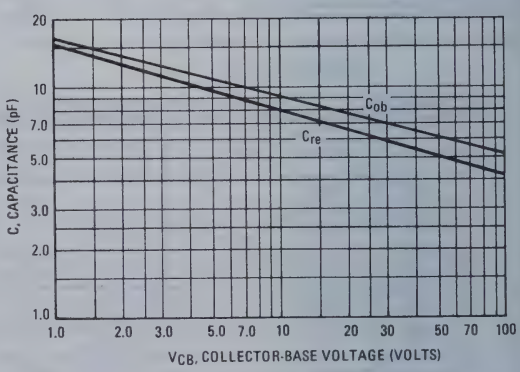


FIGURE 3 – CAPACITANCES



MJ423
MJ431

For Specifications, See MJ413 Data.

MJ424 (SILICON)
MJ425

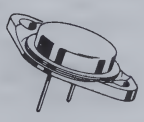
HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in high voltage applications in deflection circuits, switching regulators, inverters, and line operated amplifiers.

- High Collector-Emitter Voltage — V_{CEX} = 700 Vdc
- Excellent DC Current Gain — h_{FE} = 10 (Min) @ I_C = 2.5 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 1.0 Adc

5 AMPERE
POWER TRANSISTORS
NPN SILICON

350–400 VOLTS
100 WATTS



MAXIMUM RATINGS

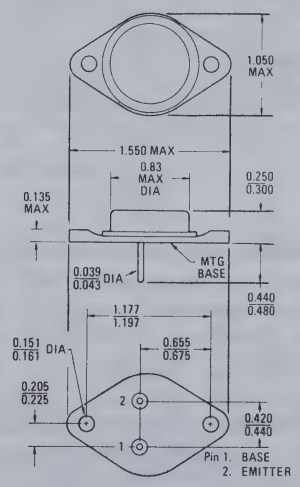
Rating	Symbol	MJ424	MJ425	Unit
Collector-Emitter Voltage	V_{CEO}	350	400	Vdc
Collector-Emitter Voltage	V_{CEX}	700		Vdc
Collector-Base Voltage	V_{CB}	700		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	MJ424 MJ425	$V_{CEO(sus)}$	 350 400	 – –	Vdc
Collector Cutoff Current (V_{CE} = 350 Vdc, I_B = 0) (V_{CE} = 400 Vdc, I_B = 0)	 MJ424 MJ425	I_{CEO}	 – –	 0.25 0.25	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{BE(off)}$ = 1.5 Vdc)		I_{CEX}	–	0.5	mAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	 30 10	 90 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.5	–	MHz



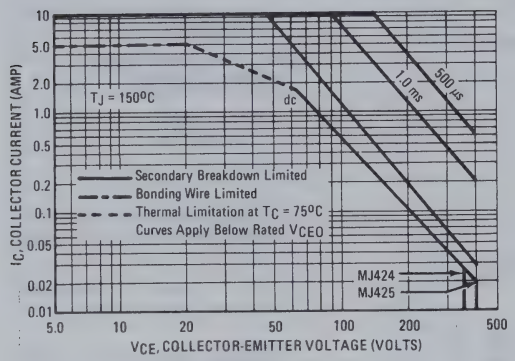
To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

FIGURE 1 – SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

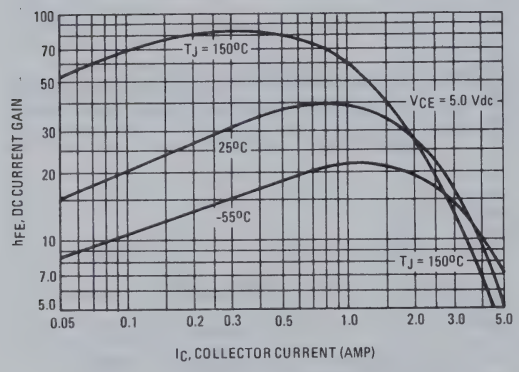


FIGURE 3 – "ON" VOLTAGES

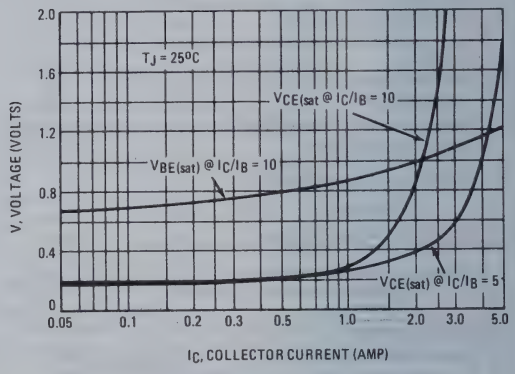


FIGURE 4 – SUSTAINING VOLTAGES TEST LOAD LINE

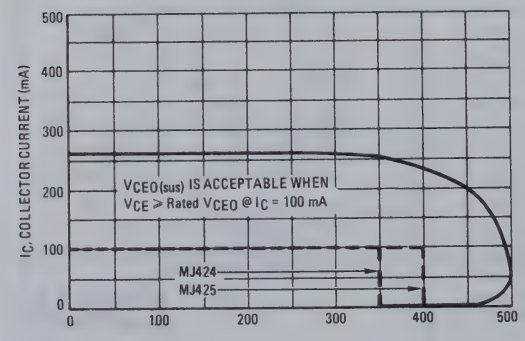
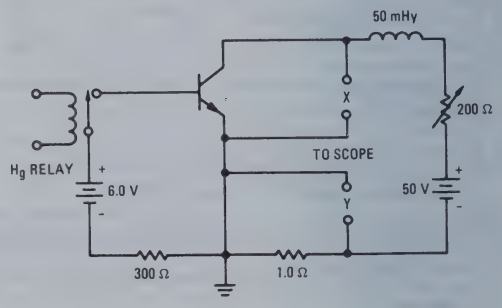


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ450 (SILICON)

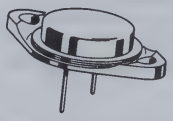
HIGH-POWER PNP SILICON TRANSISTOR

. . . designed for high-current switching and general purpose amplifier applications.

- Low Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc @ I_C = 10 Adc
- DC Current Gain — h_{FE} = 20 (Min) @ I_C = 10 Adc
- Excellent Safe Area Characteristics

30 AMPERE
POWER TRANSISTOR
PNP SILICON

40 VOLTS
150 WATTS



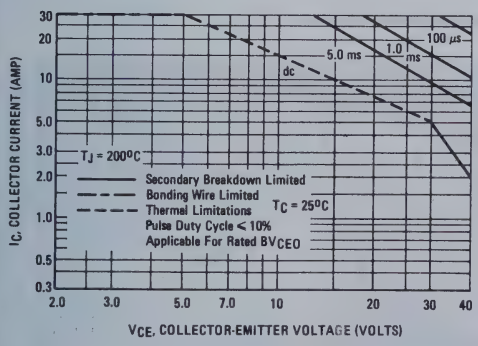
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	30	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

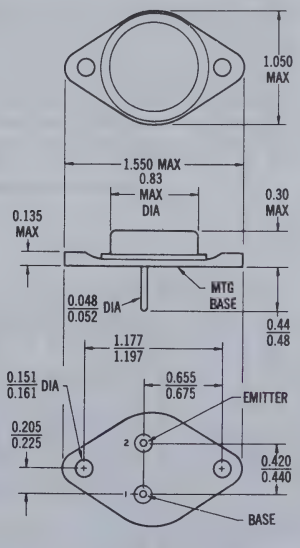
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 12
(TO-3 except Pin Diameter)
(Collector Connected to Case)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

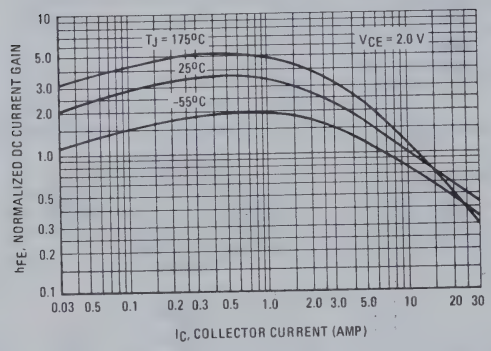


FIGURE 3 – "ON" VOLTAGES

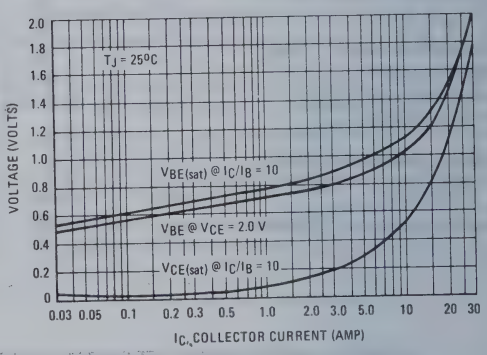
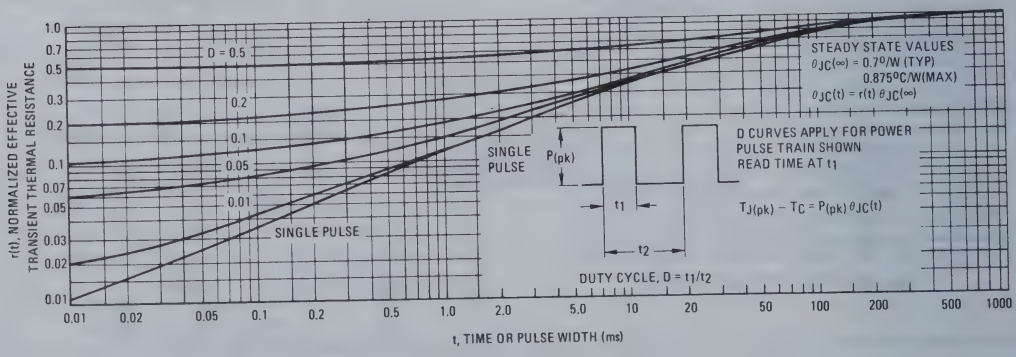


FIGURE 4 – THERMAL RESPONSE



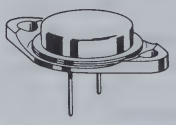
MJ480 (SILICON)
MJ481

NPN SILICON POWER TRANSISTORS

. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30-200 @ I_C = 1.0 Adc
- Complements to PNP MJ490 and MJ491

4 AMPERE
POWER TRANSISTORS
NPN SILICON
40-60 VOLTS
87.5 WATTS



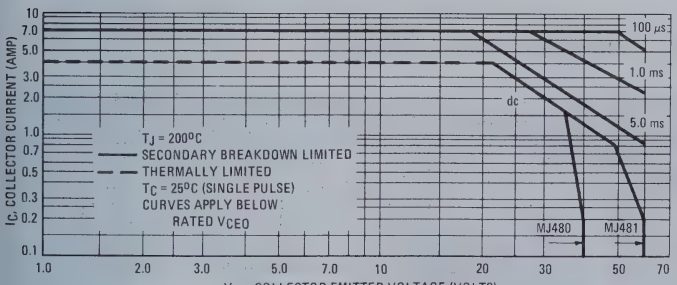
MAXIMUM RATINGS

Rating	Symbol	MJ480	MJ481	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

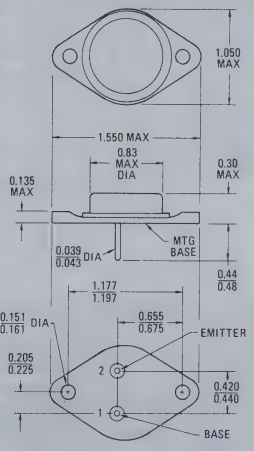
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0) MJ480 / MJ481	BV_{CEO}	40 / 60	– / –	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50	–	–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		30	200	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.4	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.2	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	–	1.0	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.5	
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		–	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

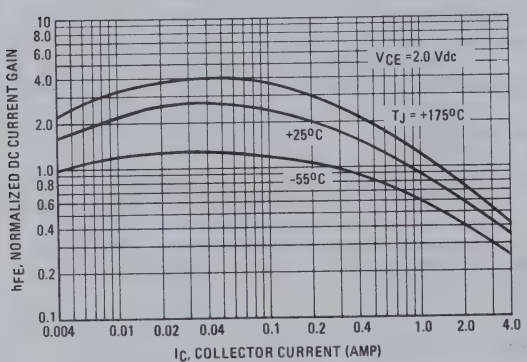


FIGURE 3 – "ON" VOLTAGES

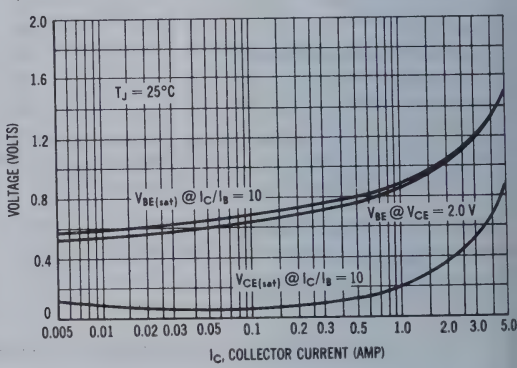
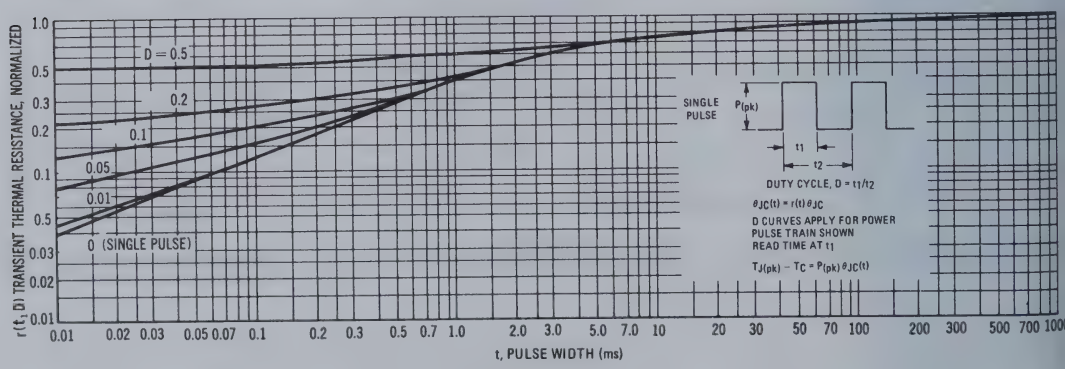


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



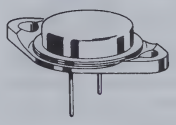
MJ490 (SILICON)
MJ491

PNP SILICON POWER TRANSISTORS

. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain–Bandwidth Product – f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain – h_{FE} = 30-200 @ I_C = 1.0 Adc
- Complements to NPN MJ480 and MJ481

4 AMPERE
POWER TRANSISTORS
PNP SILICON
40-60 VOLTS
87.5 WATTS



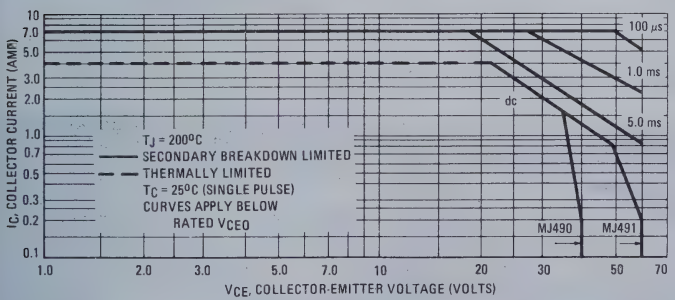
MAXIMUM RATINGS

Rating	Symbol	MJ490	MJ491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

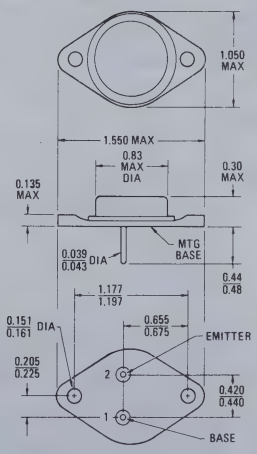
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0) MJ490	BV_{CEO}	40	–	Vdc
MJ491		60	–	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50	–	–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		30	200	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.4	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.2	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	–	1.0	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.5	
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		–	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

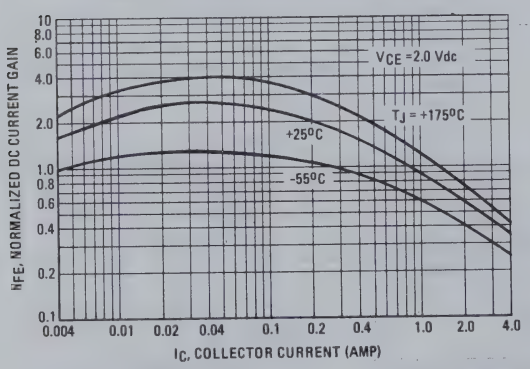


FIGURE 3 – "ON" VOLTAGE

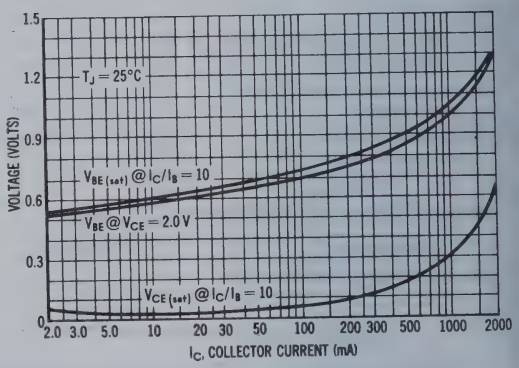
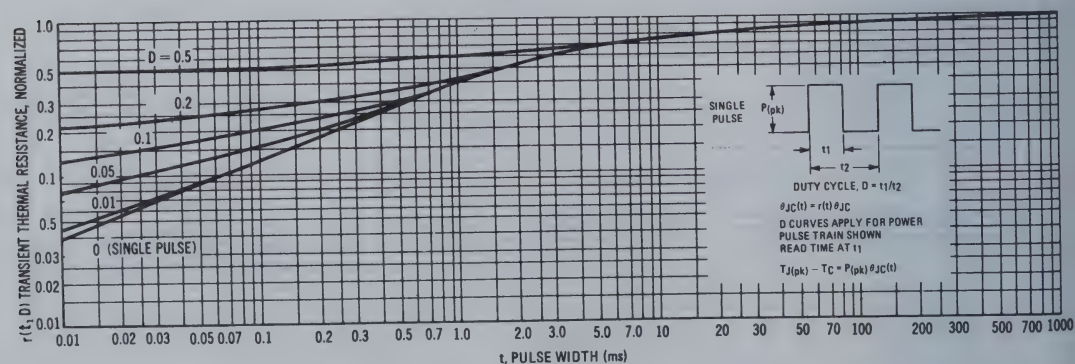


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ500 (SILICON)
MJ501

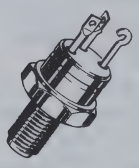
MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Collector Common to Case

7 AMPERE POWER TRANSISTORS PNP SILICON

60-80 VOLTS
60 WATTS



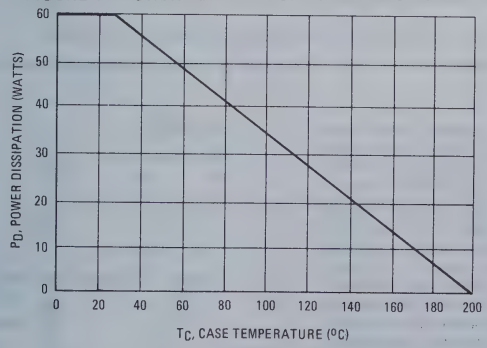
MAXIMUM RATINGS

Rating	Symbol	MJ500	MJ501	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current — Continuous	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 343		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

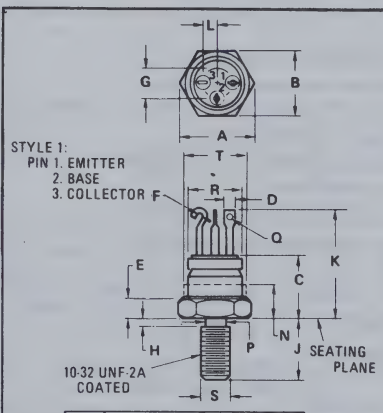
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.91	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	10.77	11.10	0.424	0.437
C	8.13	11.89	0.320	0.468
E	2.29	3.81	0.090	0.150
F	1.14	1.78	0.045	0.070
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	10.16	11.56	0.400	0.455
K	14.48	19.38	0.570	0.763
L	2.29	2.79	0.090	0.110
N	–	6.35	–	0.250
P	4.14	4.80	0.163	0.189
Q	1.02	1.65	0.040	0.065
R	8.08	9.65	0.318	0.380
S	4.212	4.310	0.1658	0.1697
T	9.65	11.10	0.380	0.437

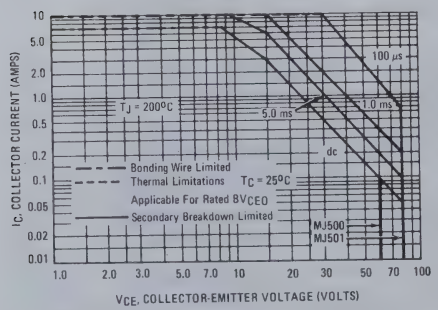
All JEDEC dimensions and notes apply
CASE 160A-03
TO-59
Collector Common to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	MJ500 MJ501	$V_{CEO(sus)}$	 60 80	 – –	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, I_B = 0) (V_{CE} = 75 Vdc, I_B = 0)	MJ500 MJ501	I_{CEO}	 – –	 100 100	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ500 MJ501 MJ500 MJ501	I_{CEX}	– – – –	10 10 1.0 1.0	μAdc mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_C = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 25 25 15	 – 180 –	–
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		$V_{CE(sat)}$	 – –	 0.7 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		$V_{BE(sat)}$	 – –	 1.2 2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_d	–	100	ns
Rise Time		t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc, I_{B1} = I_{B2} = 200 mAdc)	t_s	–	1.0	μs
Fall Time		t_f	–	150	ns

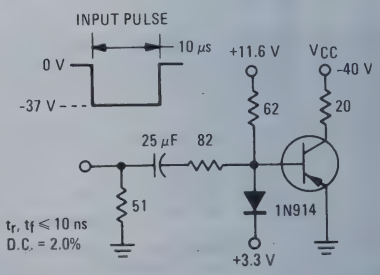
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ802 (SILICON)

HIGH-POWER NPN SILICON TRANSISTOR

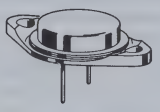
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the PNP MJ4502

30 AMPERE
POWER TRANSISTOR

NPN SILICON

100 VOLTS
200 WATTS



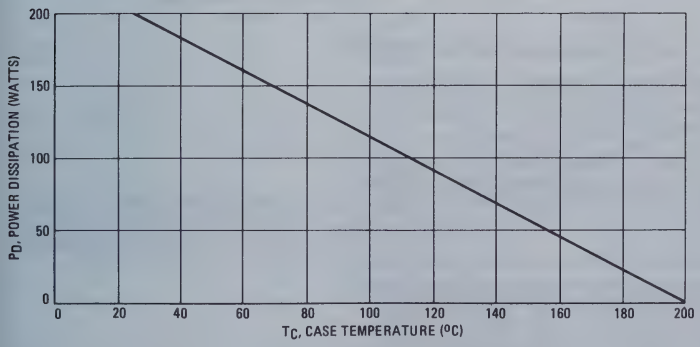
MAXIMUM RATINGS

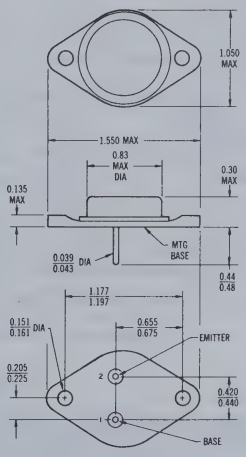
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	100	–	Vdc
Collector-Emitter Sustaining Voltage [1] (I_C = 200 mAdc)	$BV_{CEO(sus)}$	90	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)		–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter "On" Voltage* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.3	Vdc
Collector-Emitter Saturation Voltage [1] (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

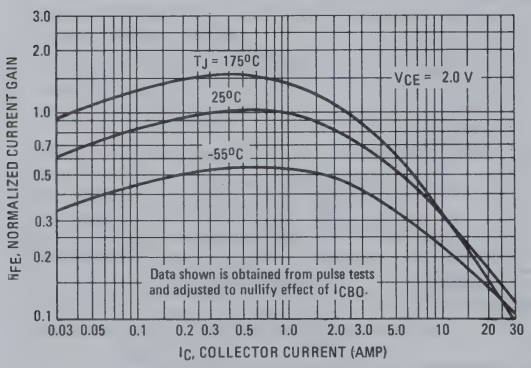


FIGURE 3 – "ON" VOLTAGES

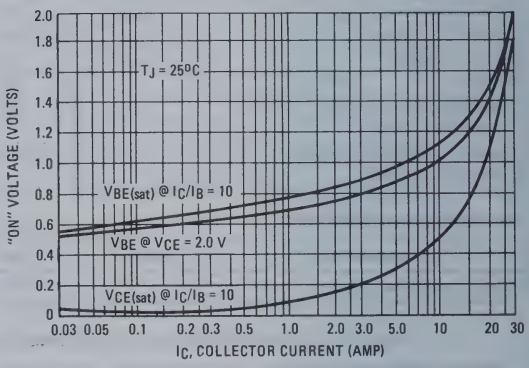
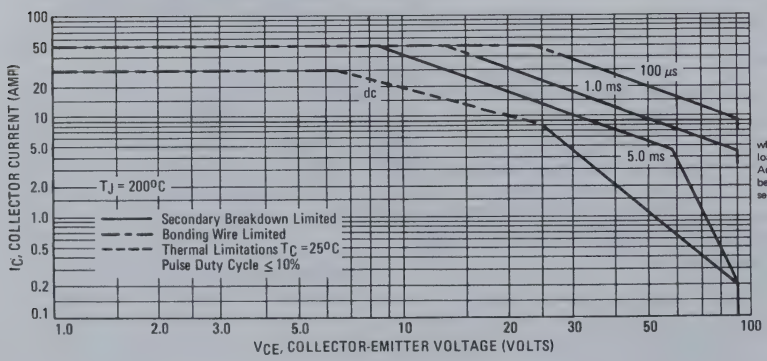


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ900, MJ901 PNP (SILICON)
MJ1000, MJ1001 NPN

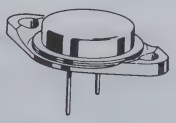
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain — h_{FE} = 6000 (Typ) @ I_C = 3.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

8.0 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60–80 VOLTS
90 WATTS



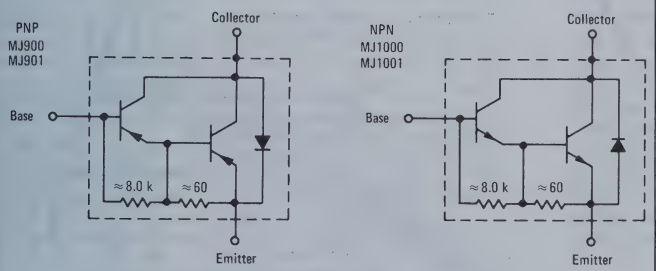
MAXIMUM RATINGS

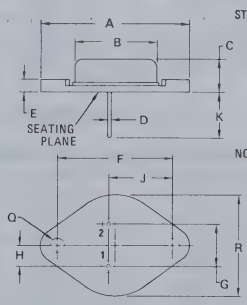
Rating	Symbol	MJ900 MJ1000	MJ901 MJ1001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	8.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	90		Watts
Derate above 25^oC		0.515		$W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.94	$^oC/W$

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, I_B = 0)	MJ900, MJ1000	BV_{CEO}	60	–	Vdc
	MJ901, MJ1001		80	–	
Collector Emitter Leakage Current		I_{CER}			mAdc
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm)	MJ900, MJ1000		–	1.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm)	MJ901, MJ1001		–	1.0	
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ900, MJ1000		–	5.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ901, MJ1001		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ900, MJ1000		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJ901, MJ1001		–	500	
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)			1000	–	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			750	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 12 mAdc)			–	2.0	
(I_C = 8.0 Adc, I_B = 40 mAdc)			–	4.0	
Base-Emitter Voltage(1) (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	2.5	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

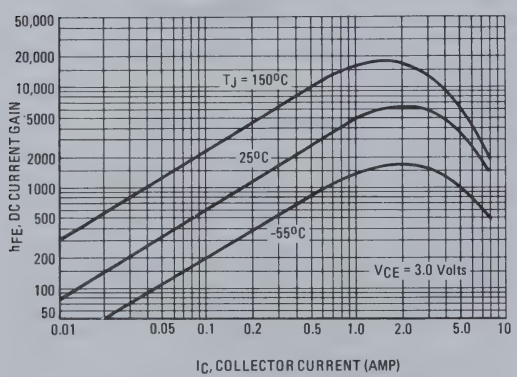


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

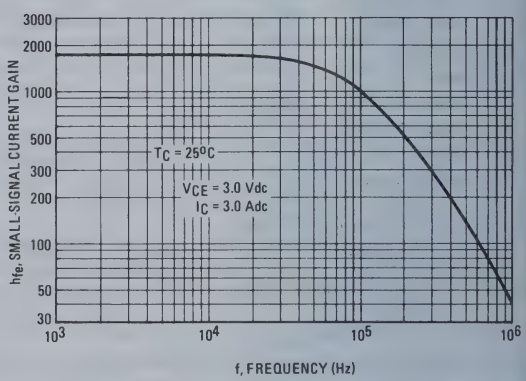


FIGURE 4 – "ON" VOLTAGES

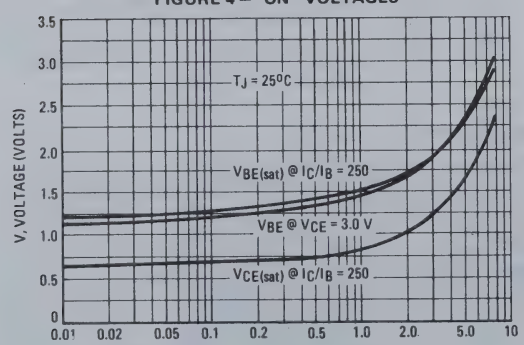
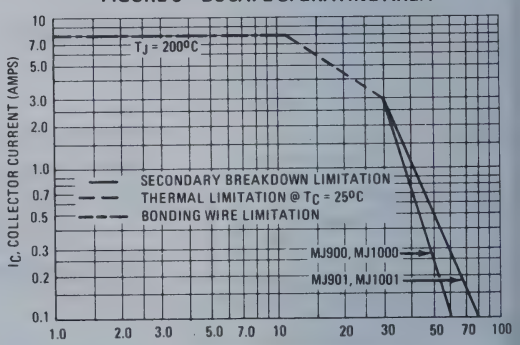


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ920, MJ921 PNP (SILICON)
MJ1200, MJ1201 NPN

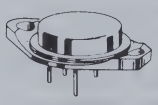
DUAL SILICON POWER DARLINGTON TRANSISTORS

. . . designed for hammer driver, regulator and amplifier applications.

- High DC Current Gain —
  h_{FE} = 3000 (Typ) @ I_C = 4.0 Adc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 60 Vdc — MJ920, MJ1200
  = 80 Vdc — MJ921, MJ1201
- Total Monolithic Construction
  Dual transistors in the same chip, yielding like electrical characteristics. Collectors are common

DUAL DARLINGTON
8 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS

60, 80 VOLTS
160 WATTS

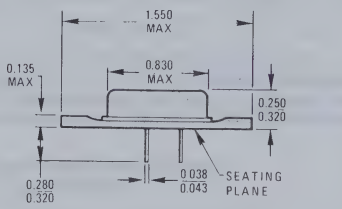


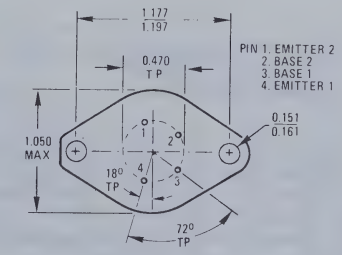
MAXIMUM RATINGS

Rating	Symbol	MJ920 MJ1200	MJ921 MJ1201	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous — Peak	I_C	8.0 16		Adc
Base Current	I_B	120		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Equal power in both transistors)	P_D	160 0.91		Watts W/°C
Single Transistor Dissipation @ T_C = 25°C Derate above 25°C	P_D	120 0.68		Watts W/°C
Operating and Storage Junction, Temperature Range	T_J,T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

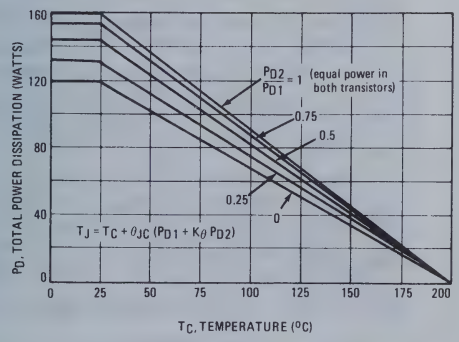
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case Single Transistor Effective, equal power both transistors	θ_{JC}	 1.46 1.10	°C/W
Thermal Coupling Factor	K_θ	50	%





CASE 253

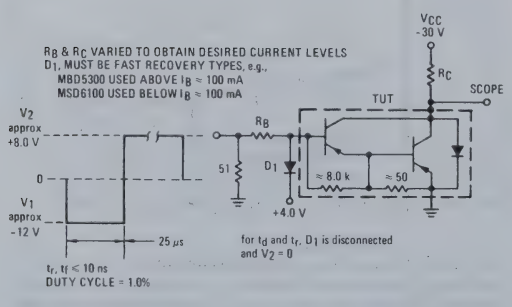
FIGURE 1 — POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	MJ920, MJ1200	$V_{CEO(sus)}$	60	–	Vdc
	MJ921, MJ1201		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ920, MJ1200		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	MJ921, MJ1201		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc)	MJ920, MJ921		–	0.5	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)	MJ1200, MJ1201		–	0.5	
(V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ920, MJ921		–	5.0	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ1200, MJ1201		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			750	18000	
(I_C = 8.0 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 16 mAdc)			–	2.0	
(I_C = 8.0 Adc, I_B = 80 mAdc)			–	3.0	
Base-Emitter Saturation Voltage (I_C = 8.0 Adc, I_B = 80 mAdc)		$V_{BE(sat)}$	–	4.0	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short Circuit Forward Current Transfer Ratio (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	4.0	–	–
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJ1200, MJ1201		–	200	
	MJ920, MJ921		–	300	
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit, reverse all polarities.

FIGURE 3 – SWITCHING TIMES

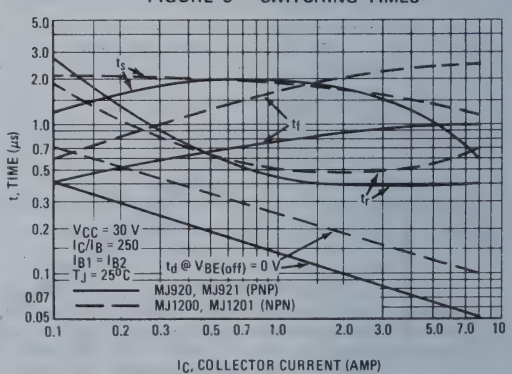


FIGURE 4 – THERMAL RESPONSE

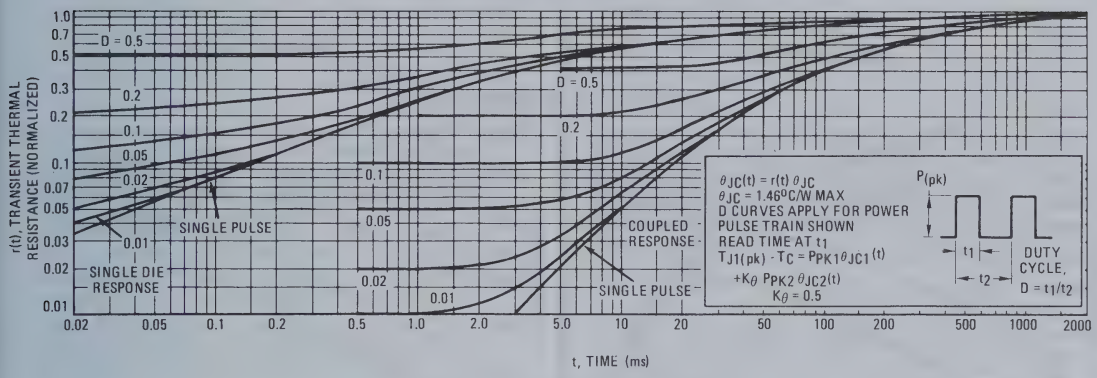
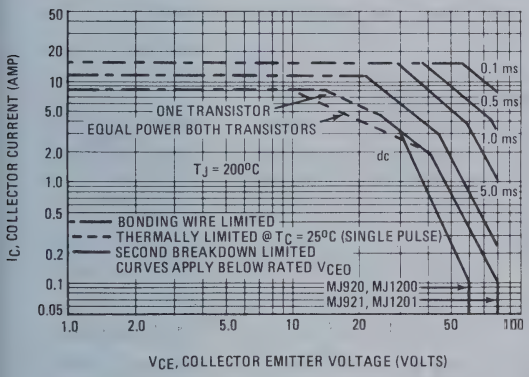


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

NOTE

Computing Peak Junction Temperature

Use $T_{J1(pk)} - T_C = P_{PK1}\theta_{JC1}(t) + K_\theta P_{PK2}\theta_{JC2}(t)$

Example: P_{PK1} = 200 W, t_1 = 5.0 ms, D = 20%; P_{PK2} = 100 W, t_1 = 10 ms, D = 20% } Pulses Coincident at Trailing Edge

Read $r(t) = 0.55$, $\therefore \theta_{JC1}(t) = 0.80$; Read $r(t) = 0.21$ (from Figure 4), $\therefore \theta_{JC2}(t) = 0.31$

$T_{J1(pk)} - T_C = (200)(0.8) + (0.5)(100)(0.31)$

$= 160 + 15 = 175^oC$

Where the side having highest junction temperature is not obvious, both sides should be checked.

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

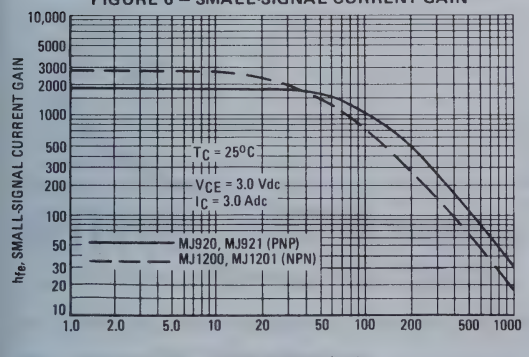
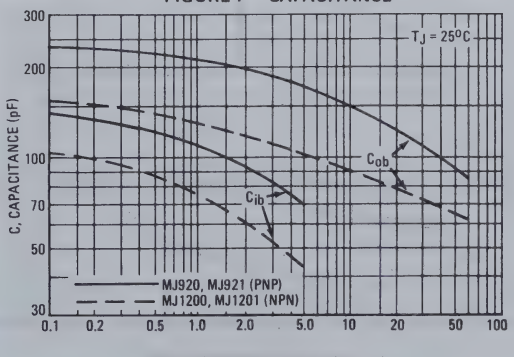


FIGURE 7 – CAPACITANCE



PNP
MJ920, MJ921

NPN
MJ1200, MJ1201

FIGURE 8 – DC CURRENT GAIN

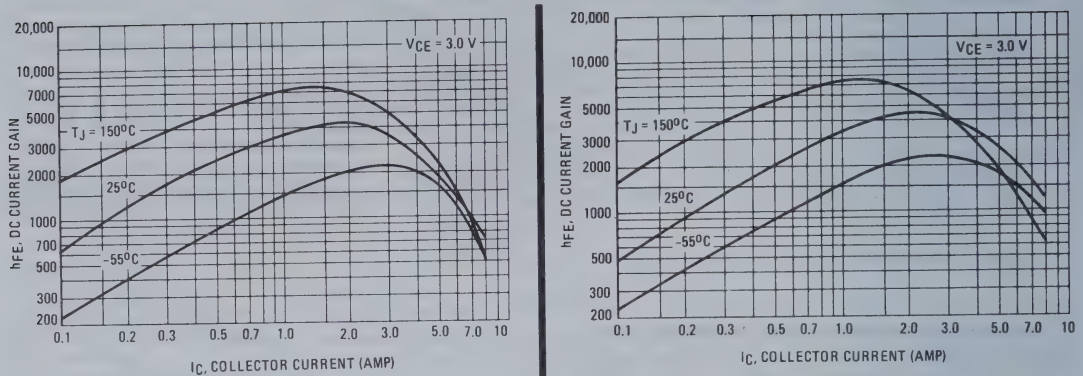


FIGURE 9 – COLLECTOR SATURATION REGION

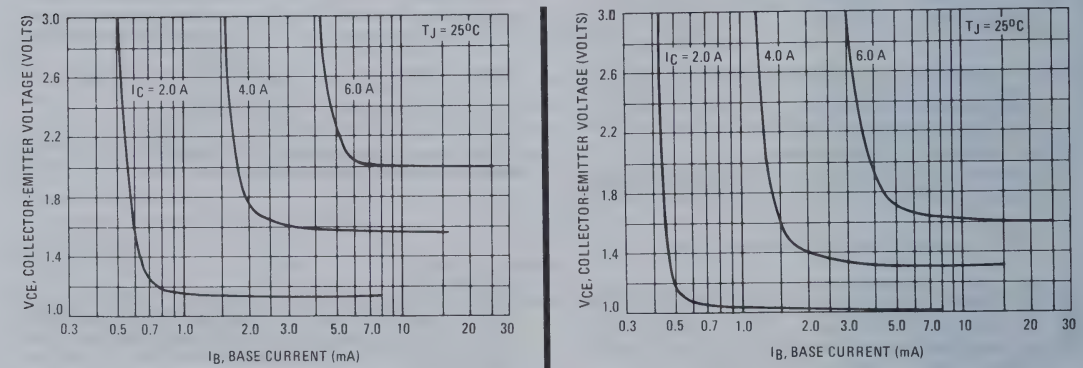
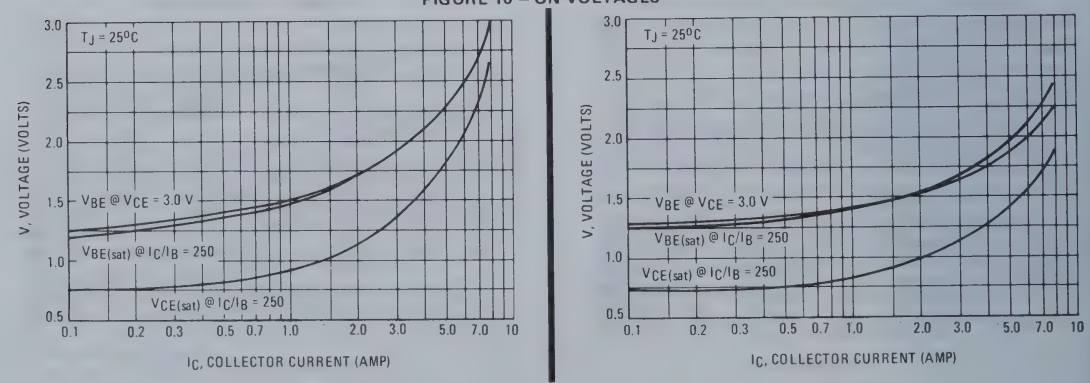


FIGURE 10 – ON VOLTAGES



PNP
MJ920, MJ921

NPN
MJ1200, MJ1201

FIGURE 11 – TEMPERATURE COEFFICIENTS

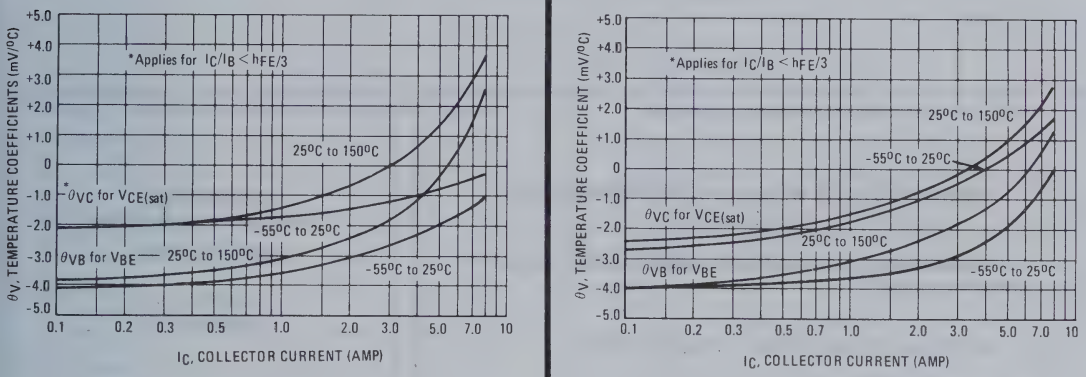


FIGURE 12 – COLLECTOR CUTOFF REGION

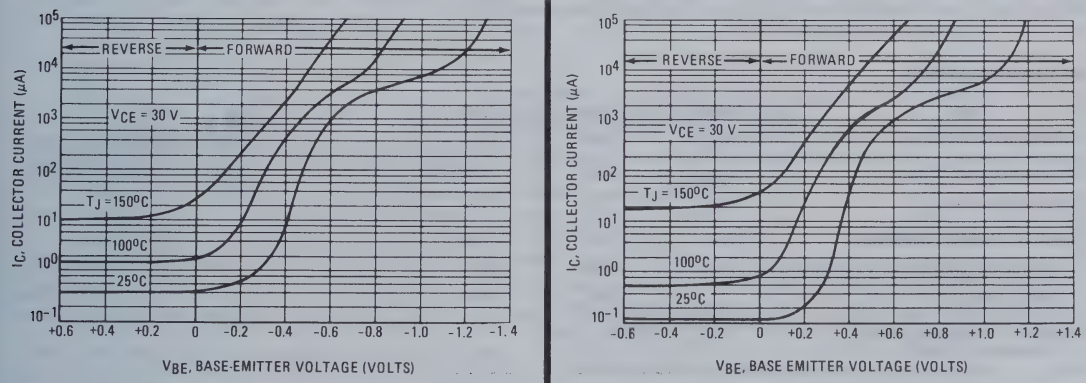
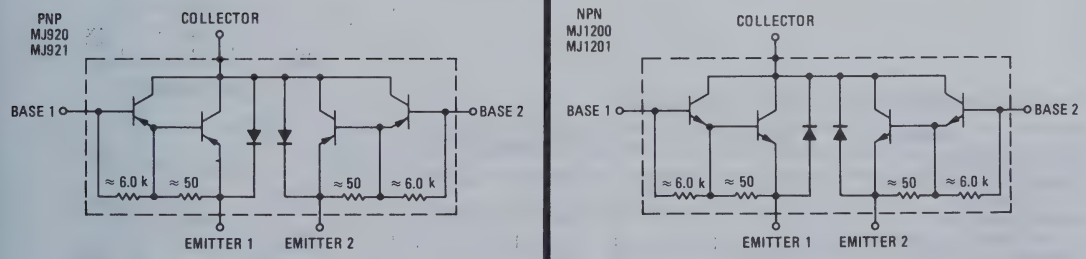


FIGURE 13 – DARLINGTON SCHEMATIC



MJ1000, MJ1001 (SILICON)

For Specifications, See MJ900 Data.

MJ1200, MJ1201 (SILICON)

For Specifications, See MJ920 Data.

MJ1800 (SILICON)

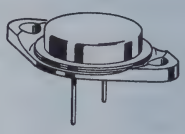
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in vertical deflection amplifier circuits in television receivers.

- High Collector-Emitter Voltage — V_{CER} = 500 Vdc
- Excellent Gain Linearity

5 AMPERES
POWER TRANSISTOR
NPN SILICON

500 VOLTS
100 WATTS

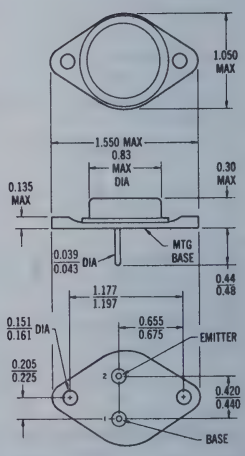


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage	V_{CER}	500	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.8	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W



Collector Connected to Case
CASE 11
TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	BV_{CEO} (1)	250	–	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms)	I_{CER}	–	200	μAdc
Emitter-Base Leakage Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)	h_{FE1} (1)	35	–	–
DC Current Gain (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE2} (1)	40	120	–
Gain Linearity	h_{FE1}/h_{FE2}	0.95	–	–

(1) Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

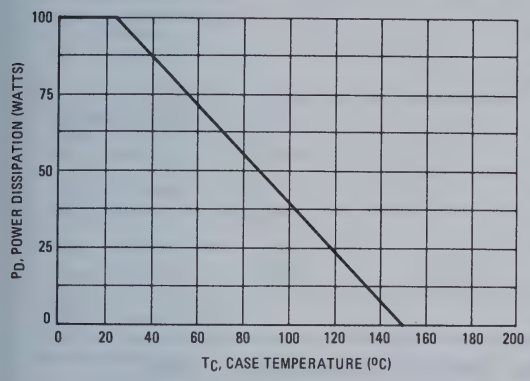


FIGURE 2 – NORMALIZED DC CURRENT GAIN

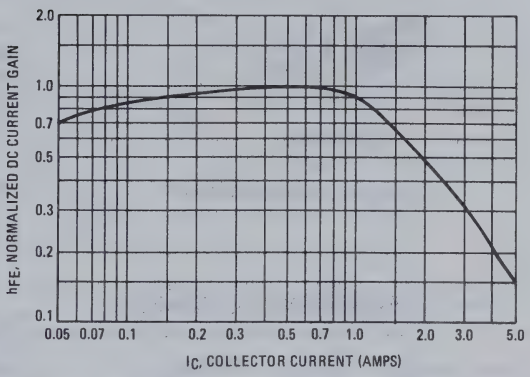
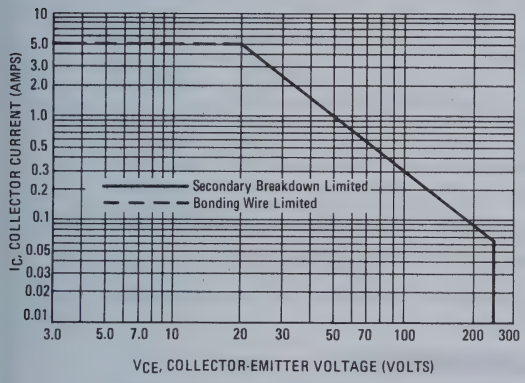


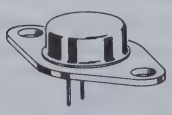
FIGURE 3 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2249 (SILICON)
MJ2250
MJ3101

Medium-power NPN silicon transistors ideal for use as drivers, switches, amplifiers.

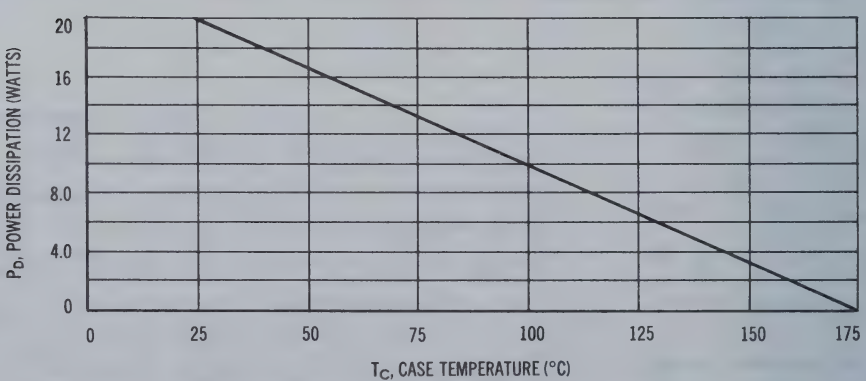


CASE 80
(TO-66)
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	MJ3101	MJ2249	MJ2250	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current - Continuous Peak	I_C	← 2.0 → ← 3.0 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 20 → ← 0.133 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →			°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



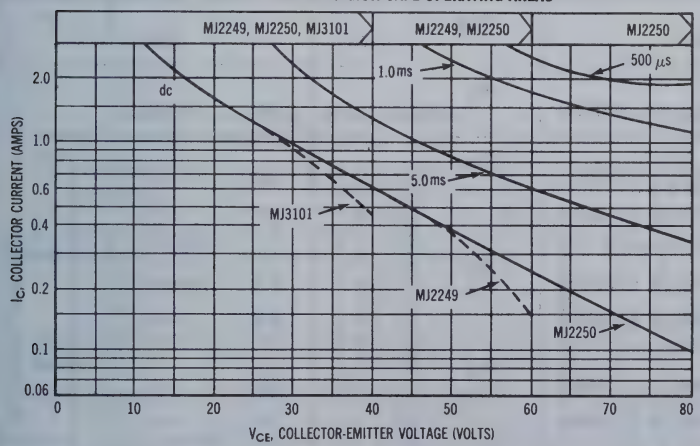
Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage (1) (I_C = 100 mAdc, I_B = 0)	MJ3101	BV_{CEO}	40	—	Vdc
	MJ2249		60	—	
	MJ2250		80	—	
Collector-Base Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MJ3101	I_{CBO}		1.0	mAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 60 Vdc, I_E = 0)	MJ2249		—	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	MJ2250		—	1.0	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
Emitter-Base Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	All Types	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	All Types	h_{FE}	25	—	—
(I_C = 100 mAdc, V_{CE} = 4.0 Vdc)†	All Types		25	200	
(I_C = 500 mAdc, V_{CE} = 4.0 Vdc)*	All Types		25*	200*	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	—	1.0	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	2.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	2.5	
Base-Emitter Saturation Voltages (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{BE(sat)}$	—	1.2	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	1.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	All Types	f_T	10	—	MHz

(1) PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2.0% †Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3766.

MJ2251 (SILICON)
MJ2252



CASE 80
(TO-66)
Collector connected to case

High-voltage NPN silicon power transistors, particularly well suited for power output stages in television, radio, phonograph and other consumer product applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MJ2251 MJ2252	V_{CEO}	 225 300	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	 10 0.125	 Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0) MJ2251 MJ2252	BV_{CEO}	 225 300	 — —	 — —	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
Emitter-Base Leakage Current (V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	200	—
Small Signal Current Gain (I_C = 20 mAdc, V_{CE} = 50 Vdc, f = 10 MHz)	h_{fe}	1.0	—	—	—
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{fe}	 — —	 40 65	 — —	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{re}	 — —	 2.5 4.0	 — —	X10-5
Input Impedance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{ie}	 — —	 150 75	 — —	ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{oe}	 — —	 5 20	 — —	μmhos

COLLECTOR CHARACTERISTICS

FIGURE 1 — MJ2251

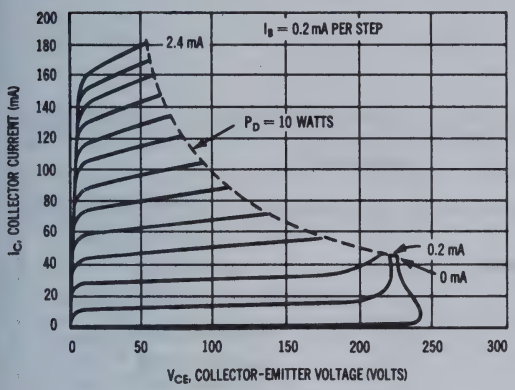


FIGURE 2 — MJ2252

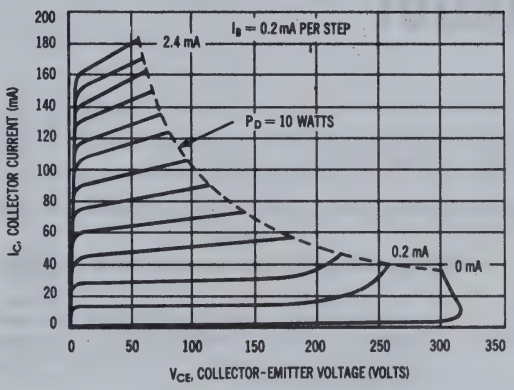


FIGURE 3 — COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

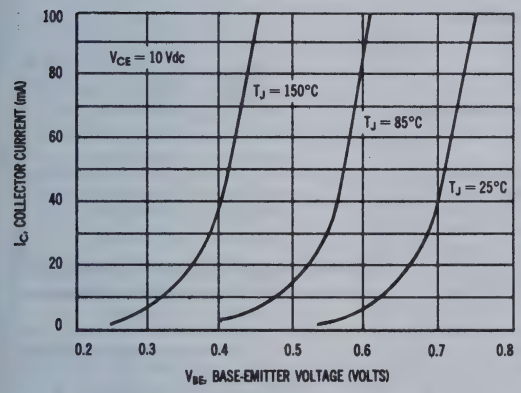


FIGURE 4 — TYPICAL LINE-OPERATED 1.5-WATT AUDIO AMPLIFIER

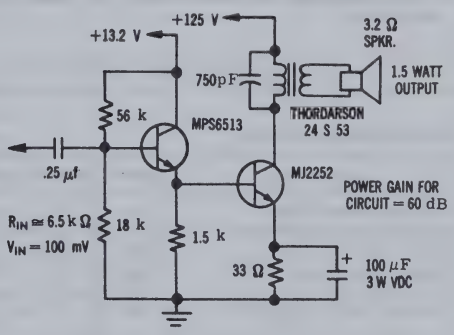


FIGURE 5 — TYPICAL TOTAL HARMONIC DISTORTION versus P_{out}

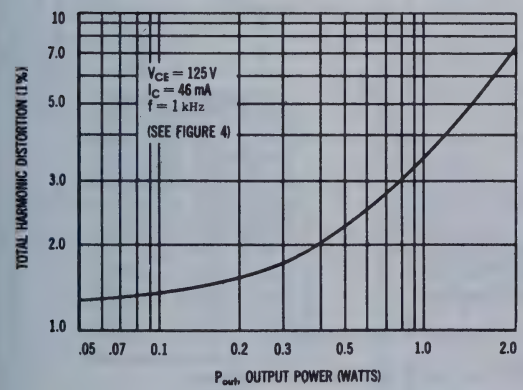
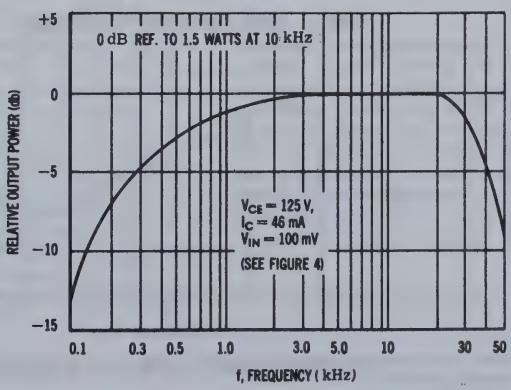


FIGURE 6 — TYPICAL FREQUENCY RESPONSE OF LINE OPERATED AUDIO AMPLIFIER



MJ2253 (SILICON)
MJ2254
MJ3701

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . ideal for use as drivers, switches, amplifiers and direct replacement of germanium medium-power devices. These devices feature:

- Low Saturation Voltage — 0.6 $V_{CE(sat)}$ @ I_C = 1.0 Adc
- h_{FE} = 15 (min) @ I_C = 500 mAdc
- Excellent Safe-Area Limits (Figure 2)
- f_T = 3.0 MHz (min)
- Recommended For Use to I_C = 1.0 Adc
- Complementary to Motorola NPN Types: MJ2249, MJ2250, MJ3101

1 AMPERE POWER TRANSISTORS

PNP SILICON

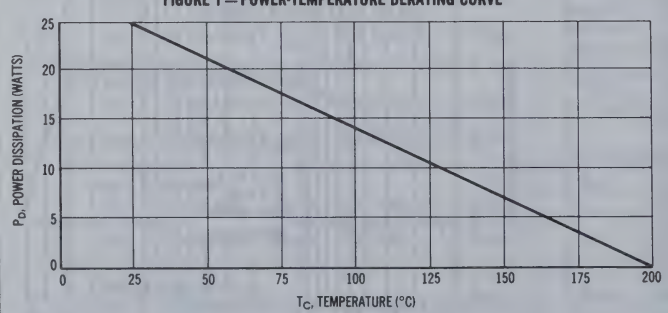
40-80 VOLTS
25 WATTS



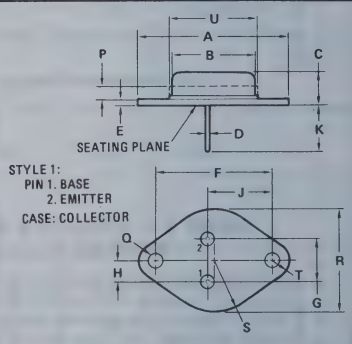
MAXIMUM RATINGS

Characteristics	Symbol	MJ3701	MJ2253	MJ2254	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}	5	7	7	Vdc
Collector Current - Continuous Peak	I_C	3.0 4.0			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.143			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and and Notes Apply.

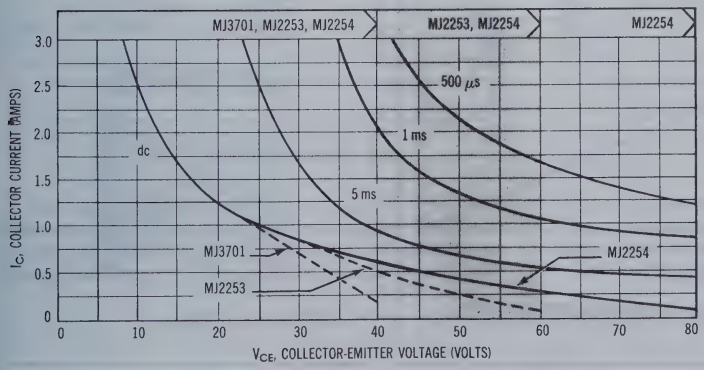
CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	MJ3701	$V_{CEO(sus)}$*	40	—	Vdc
	MJ2253		60	—	
	MJ2254		80	—	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)	MJ3701		—	1.0	
(V_{CB} = 70 Vdc, I_E = 0)	MJ2253		—	1.0	
(V_{CB} = 90 Vdc, I_E = 0)	MJ2254		—	1.0	
(V_{CB} = 40 Vdc, I_E = 0, T_C = 150°C)	MJ3701		—	2.0	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ2253		—	2.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ2254		—	2.0	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5 Vdc, I_C = 0)	MJ3701		—	2.0	
(V_{BE} = 7 Vdc, I_C = 0)	MJ2253, MJ2254		—	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 4 Vdc)†	All Types		20	—	
(I_C = 250 mAdc, V_{CE} = 4 Vdc)	All Types		20	100	
(I_C = 500 mAdc, V_{CE} = 4 Vdc)*	All Types		15	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	0.3	
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	0.8	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	1.2	
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)	All Types	f_T	3.0	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2% †Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3740, Motorola DS 3071.

MJ2267 (SILICON)
MJ2268

PNP SILICON POWER TRANSISTORS

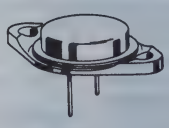
. . . designed for medium-speed switching and high-power amplifier applications. These devices can be directly substituted for germanium types.

- Low $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 4.0 Adc
- f_T = 3.0 MHz (Min)
- h_{FE} = 20-100 @ I_C = 4.0 Adc
- Excellent Safe Area Limits (Figures 2 and 3)
- Recommended For Use to I_C = 4.0 Adc

5 AMPERES
POWER TRANSISTORS

PNP SILICON

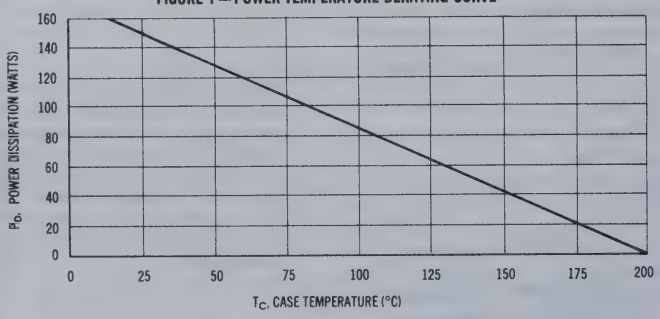
40-55 VOLTS
150 WATTS



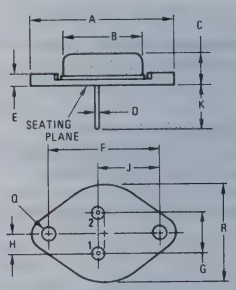
MAXIMUM RATINGS

Characteristic	Symbol	MJ2267	MJ2268	Unit
Collector-Emitter Voltage	V_{CEO}	40	55	Vdc
Collector-Base Voltage	V_{CB}	40	55	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current - Continuous	I_C	5.0		Adc
Base Current	I_B	3		Adc
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figures 2, 3. Both limits are applicable and must be observed.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	--	39.37	--	1.550
B	--	21.08	--	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	--	3.43	--	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	--	26.67	--	1.050

Collector connected to case.

CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	MJ2267	$V_{CEO(sus)}$	40	—	Vdc
	MJ2268		55	—	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc)	MJ2267		—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	MJ2268		—	1.0	
(V_{CE} = 20 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2267		—	5.0	
(V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2268		—	5.0	
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	Both Types		20	—	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)(1)	Both Types		20	100	
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc)	Both Types	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc)	Both Types	$V_{BE(sat)}$	—	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)		f_T	3.0	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE REGION SAFE OPERATING AREAS

FIGURE 2 — MJ2267

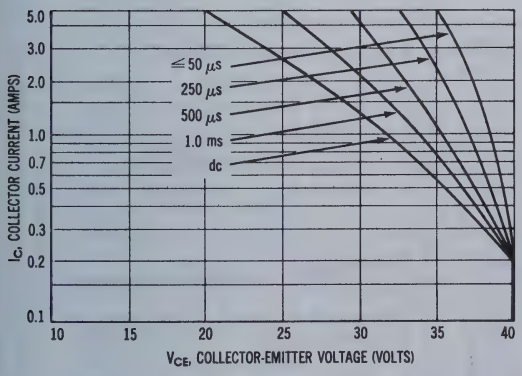
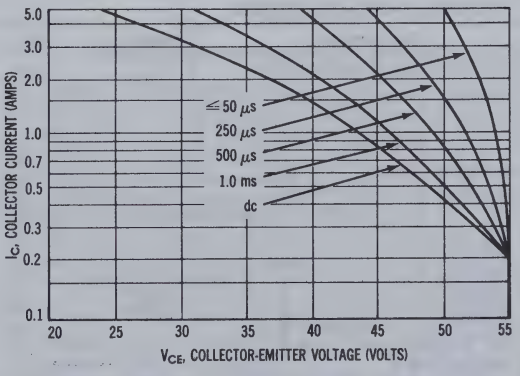


FIGURE 3 — MJ2268



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

NOTE: For additional design curves, please refer to Type 2N3789.

MJ2500, MJ2501 PNP (SILICON)
MJ3000, MJ3001 NPN

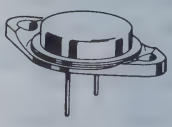
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 4000 (Typ) @ I_C = 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

10 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60–80 VOLTS
150 WATTS



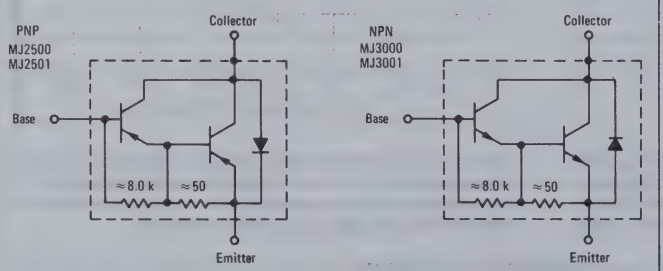
MAXIMUM RATINGS

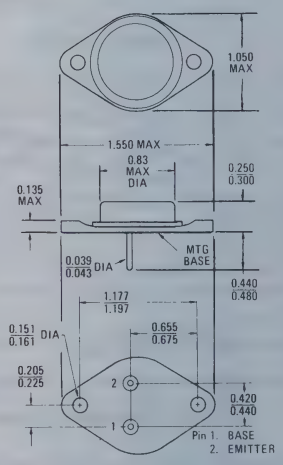
Rating	Symbol	MJ2500 MJ3000	MJ2501 MJ3001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	10		Adc
Base Current	I_B	0.2		Adc
Total Device Dissipation @ T_C = 25°C	P_D	150		Watts
Derate above 25°C		0.857		W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, I_B = 0)	MJ2500, MJ3000	BV_{CEO}	60	–	Vdc
	MJ2501, MJ3001		80	–	
Collector Emitter Leakage Current		I_{CER}			mAdc
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm)	MJ2500, MJ3000		–	1.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm)	MJ2501, MJ3001		–	1.0	
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ2500, MJ3000		–	5.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ2501, MJ3001		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ2500, MJ3000		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	MJ2501, MJ3001		–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 5.0 Adc, I_B = 20 mAdc)			–	2.0	
(I_C = 10 Adc, I_B = 50 mAdc)			–	4.0	
Base-Emitter Voltage (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	3.0	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

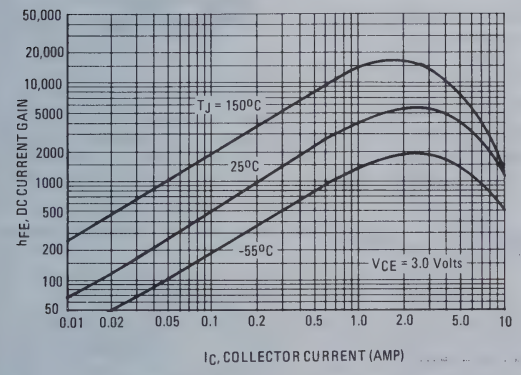


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

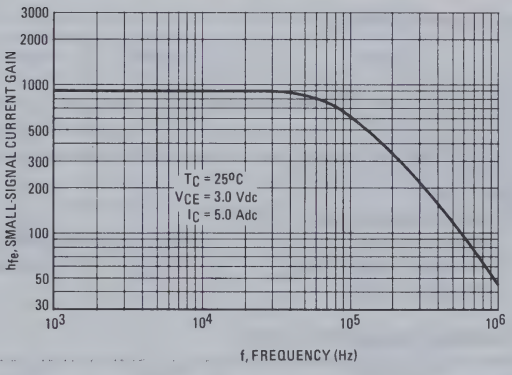


FIGURE 4 – "ON" VOLTAGES

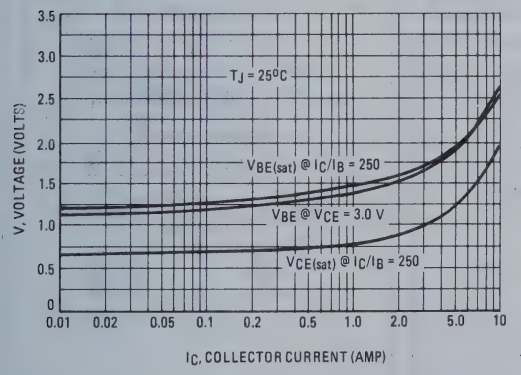
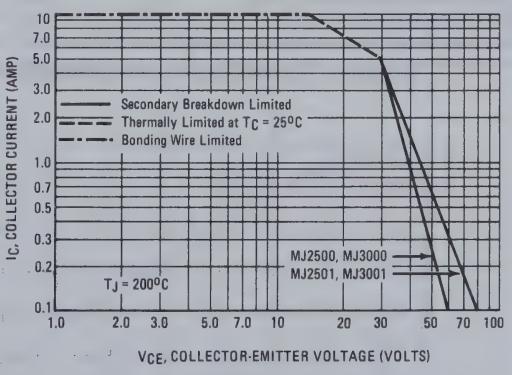


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ2801 NPN (SILICON)
MJ2901 PNP

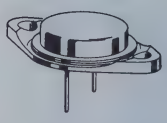
COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and switching circuit applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc (Max) @ I_C = 8.0 Adc
- DC Current Gain –
  h_{FE} = 15 (Min) @ I_C = 8.0 Adc

15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

40 VOLTS
115 WATTS



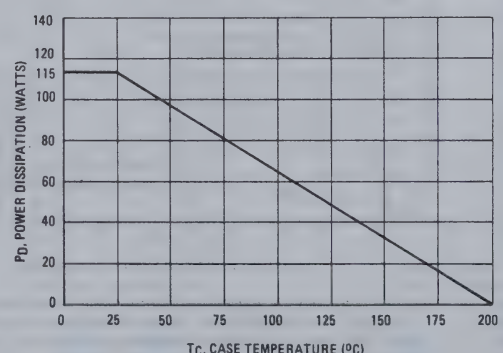
MAXIMUM RATINGS

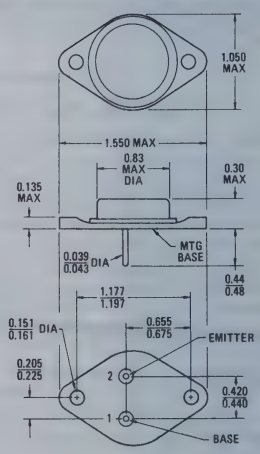
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.657	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	°C/W

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





CASE 11
(TO-3)

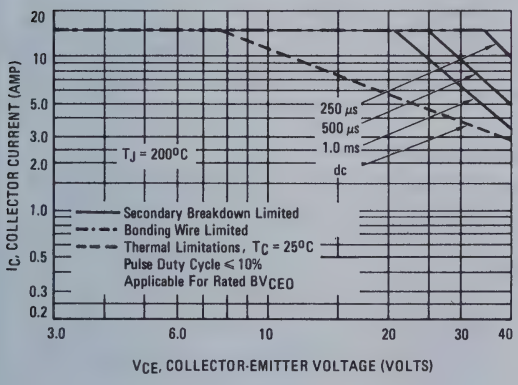
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	5.0	mAdc
Collector Cutoff Current	I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)		–	5.0	
(V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)		–	10	
Emitter Cutoff Current (V_{EB} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	15	60	–
Collector-Emitter Saturation Voltage(1) (I_C = 8.0 Adc, I_B = 0.8 Adc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter On Voltage(1) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	2.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 0.4 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	1.0	–	MHz

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

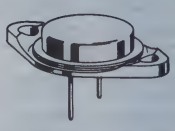
MJ2840 (SILICON)
MJ2841

HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 – 100 @ I_C = 3.0 Adc (MJ2840)
  = 4.0 Adc (MJ2841)
- Complement to PNP MJ2940 and MJ2941

10 AMPERE
POWER TRANSISTORS
NPN SILICON
60–80 VOLTS
150 WATTS



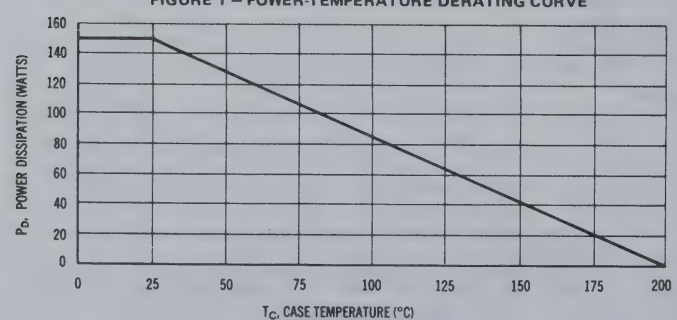
MAXIMUM RATINGS

Rating	Symbol	MJ2840	MJ2841	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

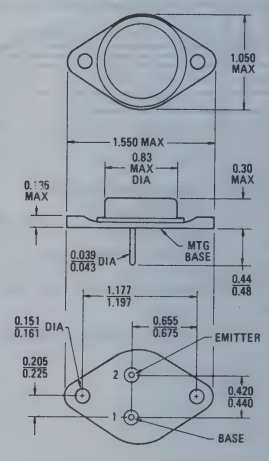
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



CASE 11
(TO-3)
Collector Connected to Case

MJ2840, MJ2841 (continued)

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	MJ2840 MJ2841	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)	Both Types		0.1	–	
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)	Both Types		2.0	–	
Base-Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	Both Types	I_{EBO}	1.0	–	mAdc
ON CHARACTERISTICS					
DC Current Gain[1]		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types		40	–	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		20	100	
Base-Emitter On Voltage[1]		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840		–	1.3	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	20	MHz

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

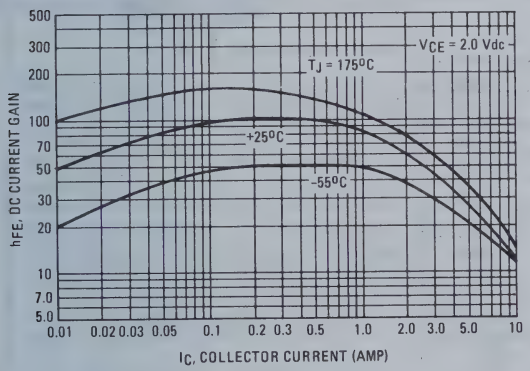


FIGURE 3 – "ON" VOLTAGES

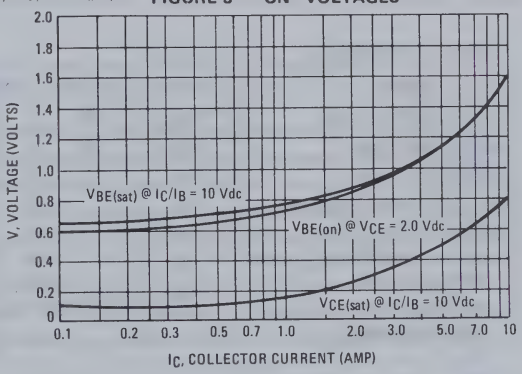
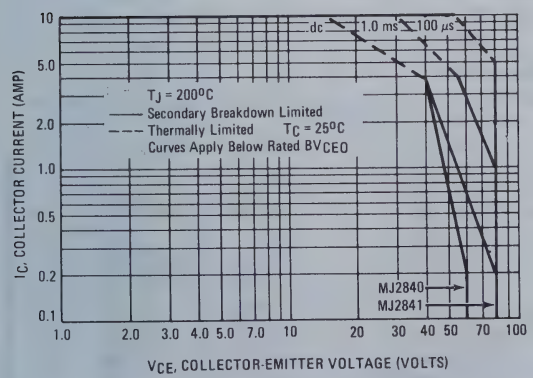


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2901 (SILICON)

For Specifications, See MJ2801 Data.

MJ2940 (SILICON)
MJ2941

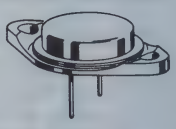
HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2940)
  = 4.0 Adc (MJ2941)
- Complement to NPN MJ2840 and MJ2841

10 AMPERE
POWER TRANSISTORS
PNP SILICON
60–80 VOLTS
150 WATTS

DS 3148



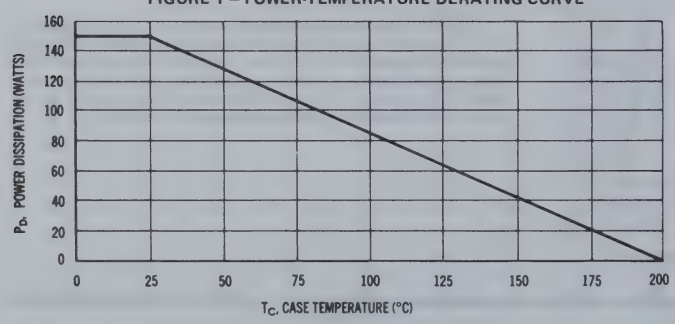
MAXIMUM RATINGS

Rating	Symbol	MJ2940	MJ2941	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

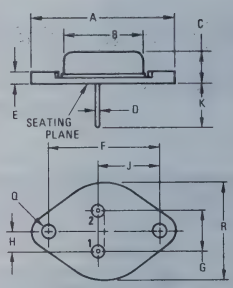
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	MJ2940 MJ2941	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	0.1	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)			–	3.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types	h_{FE}	40	–	–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2941		20	100	
Base-Emitter On Voltage(1) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940	$V_{BE(on)}$	–	1.3	Vdc
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJ2941		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		f_T	4.0	20	MHz

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

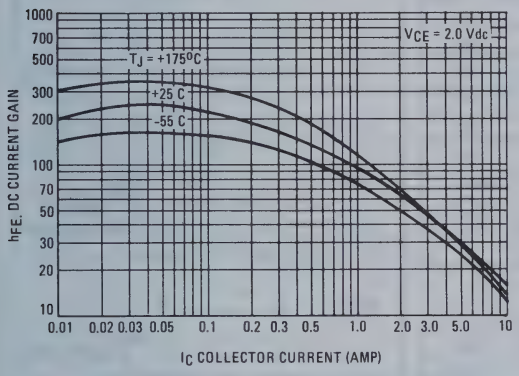


FIGURE 3 – "ON" VOLTAGES

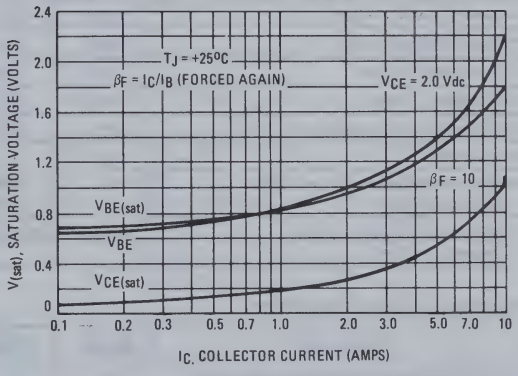
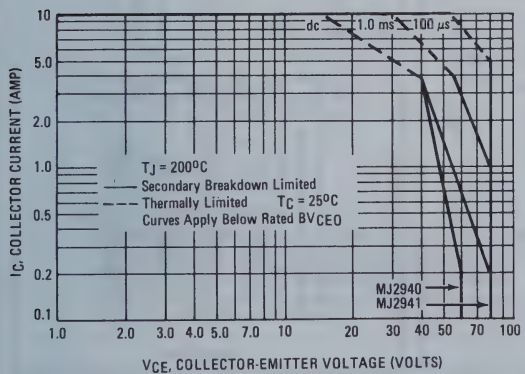


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2955 (SILICON)

PNP SILICON POWER TRANSISTOR

. . . designed for general-purpose switching and amplifier applications.

- DC Current Gain – h_{FE} = 20-70 @ I_C = 4.0 Adc
- Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.1 Vdc (Max) @ I_C = 4.0 Adc
- Excellent Safe Operating Area
- Complement to Motorola's "Epi-Base" Transistor, 2N3055

15 AMPERE
POWER TRANSISTOR

PNP SILICON

60 VOLTS
150 WATTS

DS 3215



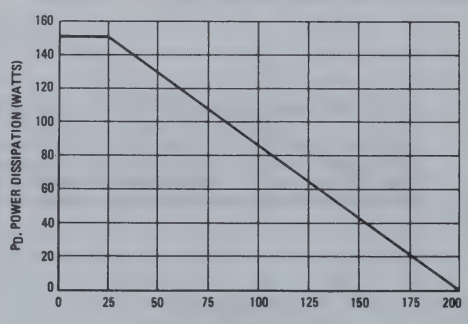
MAXIMUM RATINGS

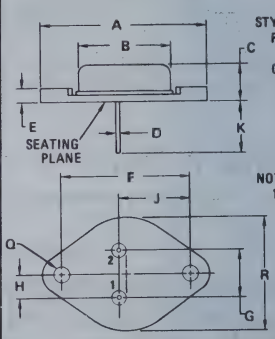
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER DERATING





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

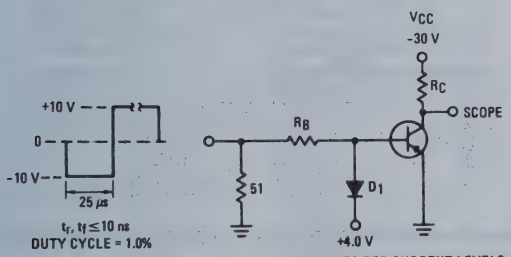
CASE 11-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	70	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 400 mAdc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	– –	1.1 3.0	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	15	–	–
Small-Signal Current Gain Cutoff Frequency (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	$f_{\alpha e}$	10	–	kHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

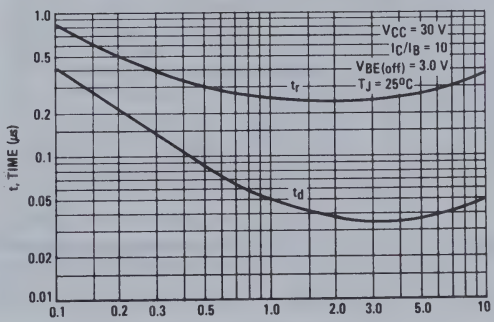


FIGURE 4 – THERMAL RESPONSE

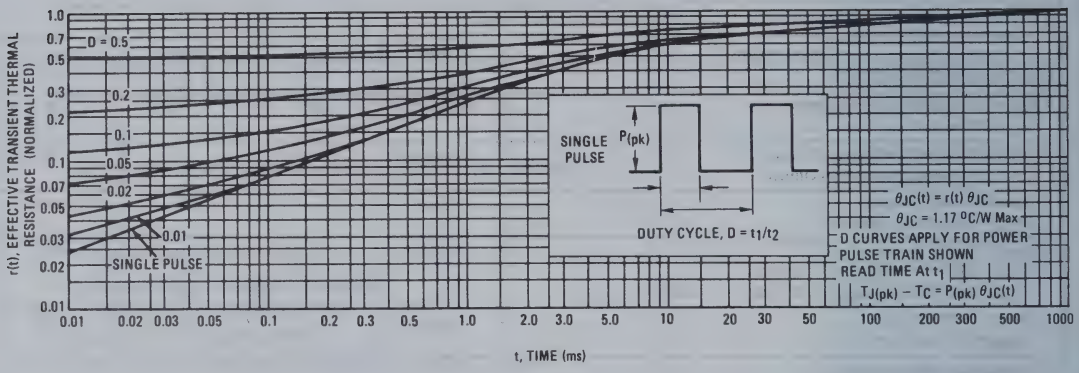
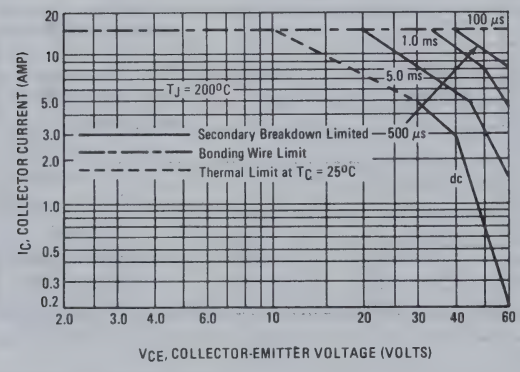


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \approx 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

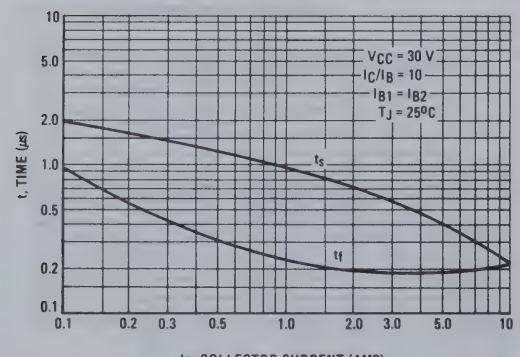


FIGURE 7 – CAPACITANCE

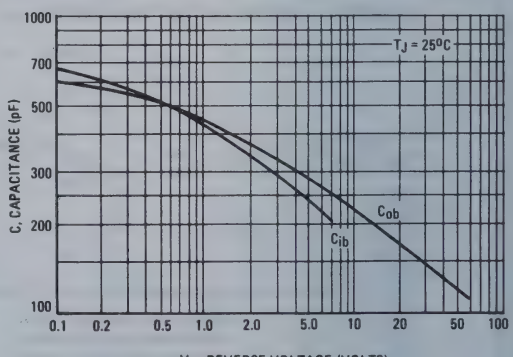


FIGURE 8 – DC CURRENT GAIN

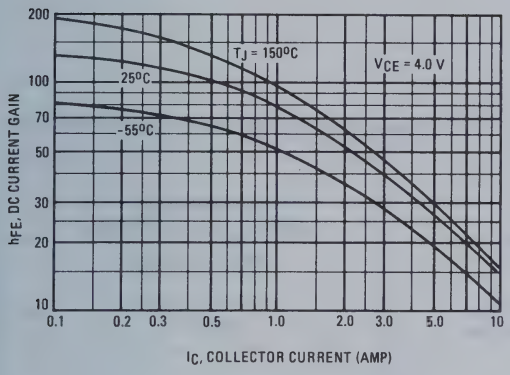


FIGURE 9 – COLLECTOR SATURATION REGION

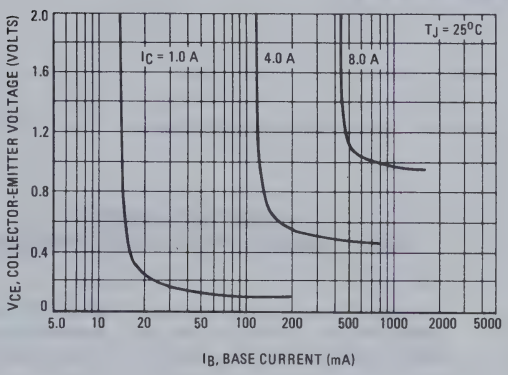


FIGURE 10 – "ON" VOLTAGES

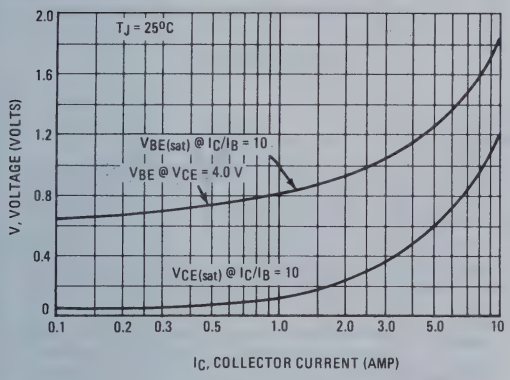


FIGURE 11 – TEMPERATURE COEFFICIENTS

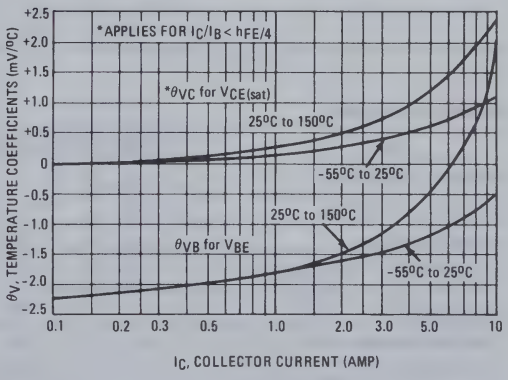


FIGURE 12 – COLLECTOR CUTOFF REGION

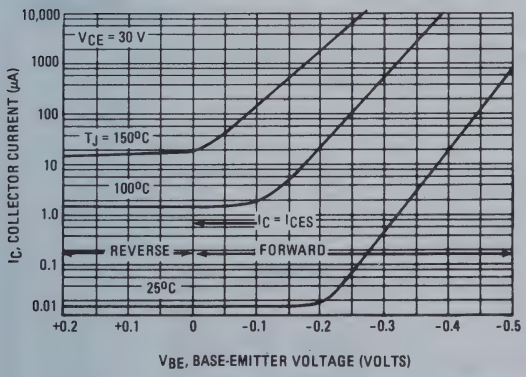
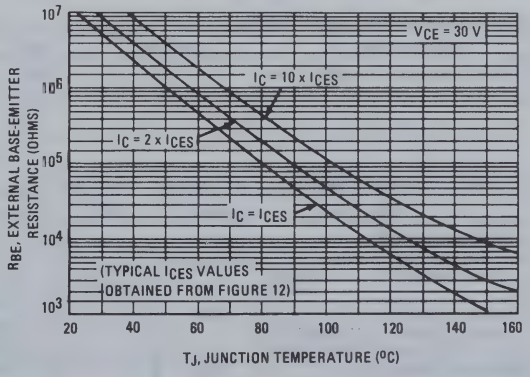


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



MJ3000, MJ3001 (SILICON)

For Specifications, See MJ2249 Data.

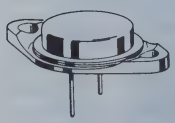
MJ3026 (SILICON)
MJ3027

VERTICAL OUTPUT
HIGH-VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in class A vertical deflection in television receivers, where linear h_{FE} is desired to 250 mA. Intended for use with high supply voltage (80-120 Vdc); ideal for line operated receivers.

2 AMPERES
POWER TRANSISTORS
NPN SILICON

500, 700 VOLTS
80 WATTS



MAXIMUM RATINGS

Rating	Symbol	MJ3026	MJ3027	Unit
Collector-Emitter Voltage	V_{CEO}	275	300	Vdc
Collector-Emitter Voltage	V_{CER}	500	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	80 0.64		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

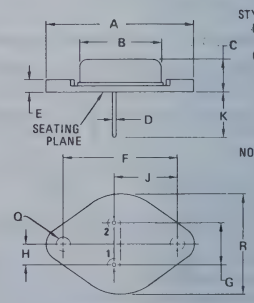
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.56	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0) MJ3026 MJ3027	$V_{CEO(sus)}$	 275 300	 – –	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms) MJ3026 (V_{CE} = 700 Vdc, R_{BE} = 1.5 k Ohms) MJ3027	I_{CER}	 – –	 200 200	μAdc
Emitter-Base Leakage Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	500	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE1}	25	–	–
DC Current Gain(1) (I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	h_{FE2}	25	–	–
Gain Linearity	h_{FE1}/h_{FE2}	0.95	–	–

(1) Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

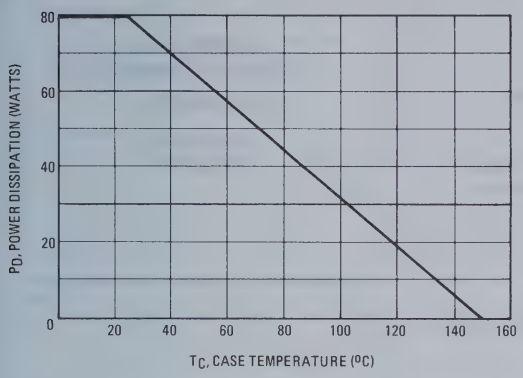


FIGURE 2 – DC CURRENT GAIN

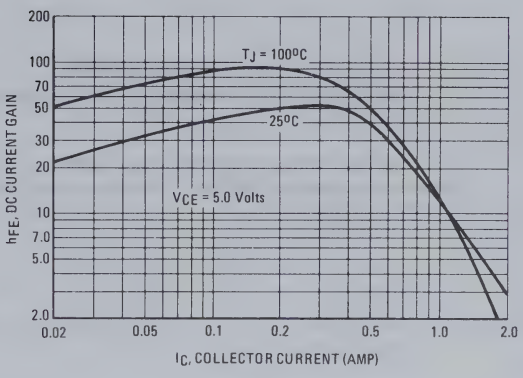
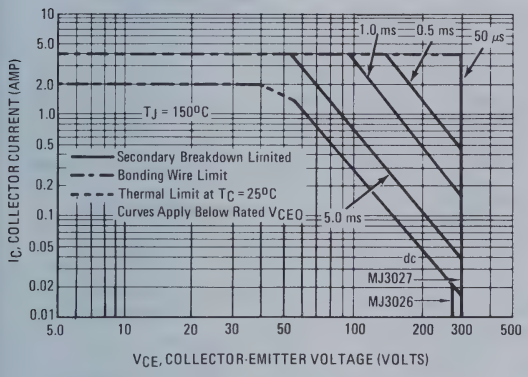


FIGURE 3 – ACTIVE-REGION DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

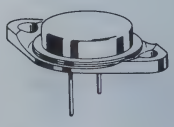
MJ3028 (SILICON)

VERTICAL OUTPUT
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in class A vertical deflection circuits where linear h_{FE} is desired to 400 mA. Primarily intended for 110° color television receivers.

3.5 AMPERES
POWER TRANSISTOR
NPN SILICON

700 VOLTS
100 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Emitter Voltage	V_{CER}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	3.5	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	100 0.8	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

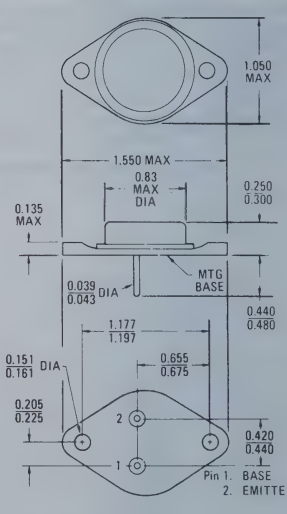
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	$V_{CEO(sus)}$	300	–	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, R_{BE} = 1.5 k Ohms)	I_{CER}	–	200	μAdc
Emitter-Base Leakage Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	500	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)	h_{FE1}*	25	–	–
DC Current Gain* (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE2}*	30	–	–
Gain Linearity	h_{FE2}/h_{FE1}	0.95	–	–

*Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.



All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

FIGURE 1 – POWER-TEMPERATURE DERATING

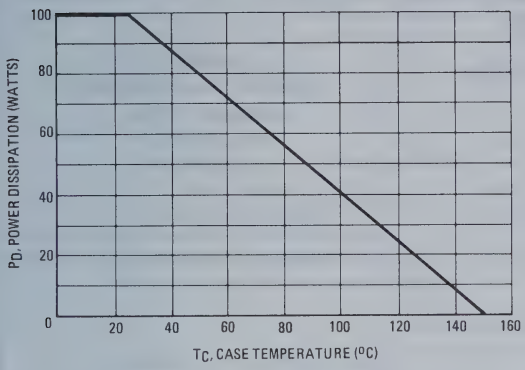


FIGURE 2 – DC CURRENT GAIN

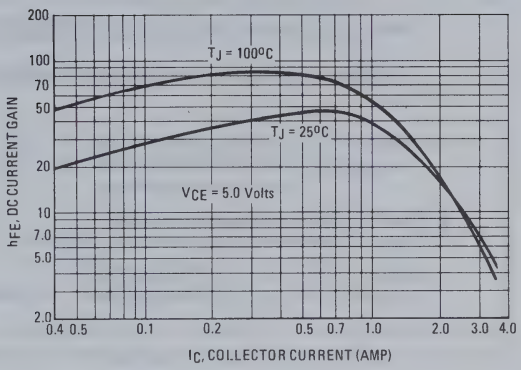
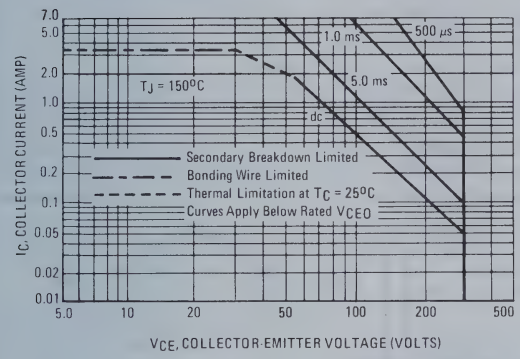


FIGURE 3 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

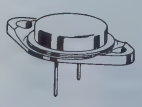
MJ3029 (SILICON)
MJ3030

NPN SILICON HIGH-VOLTAGE TRANSISTORS

. . . designed for TV horizontal and vertical deflection amplifier circuits.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 250 Vdc (Min) MJ3029
  325 Vdc (Min) MJ3030
- Fast Fall Time in Horizontal Deflection —
  t_f = 1.0 μs (Max) @ V_{CC} = 80 Vdc — MJ3030
- Excellent Gain Linearity for Vertical Deflection —
  h_{fe} @ 0.4 Adc, h_{fe} @ 0.3 Adc = 0.95 (Min) — MJ3029

5 AMPERE
POWER TRANSISTORS
NPN SILICON
250–325 VOLTS
125 WATTS



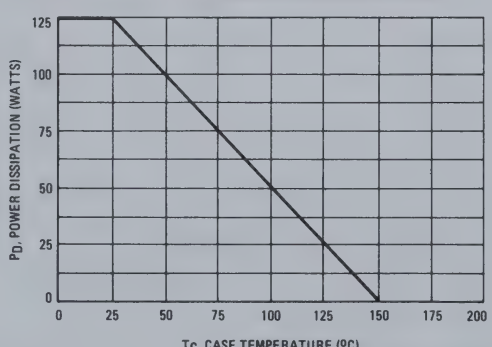
MAXIMUM RATINGS

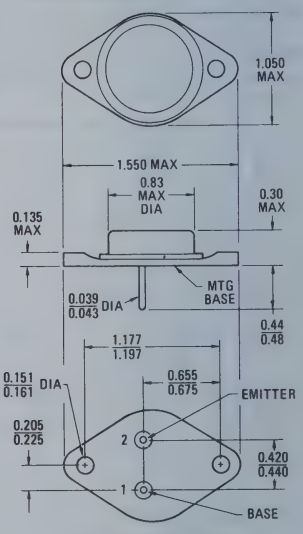
Rating	Symbol	MJ3029	MJ3030	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Emitter Voltage	V_{CER}	500	—	Vdc
Collector-Emitter Voltage	V_{CEX}	—	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





Collector Connected to Case
CASE 11
TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 0.1 Adc, I_B = 0)	MJ3029 MJ3030	$V_{CEO(sus)}$	250 325	– –	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms)	MJ3029	I_{CER}	–	1.0	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ3030	I_{CEX}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)(1) (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)(1)	MJ3029 MJ3029	h_{FE1} h_{FE2}	25 30	– –	–
Gain Linearity	MJ3029	$\frac{h_{FE2}}{h_{FE1}}$	0.95	–	–
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.8 Adc)	MJ3030	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS					
Fall Time (V_{CC} = 80 Vdc, I_C = 3.0 Adc, I_{B1} = 0.8 Adc) Figure 3	MJ3030	t_f	–	1.0	μs

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

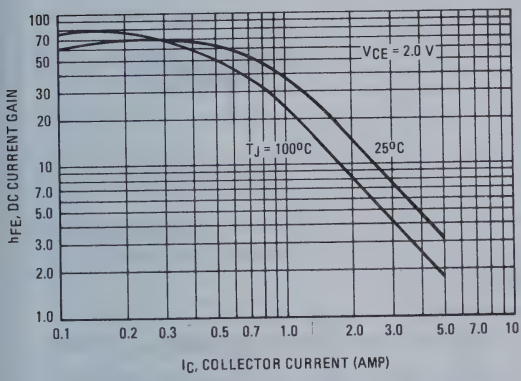
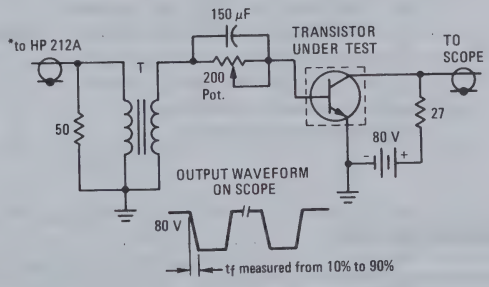
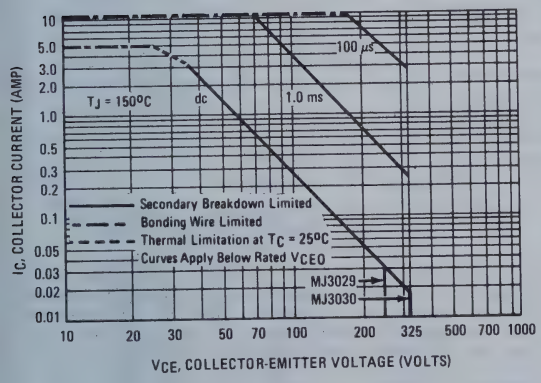


FIGURE 3 – TEST FOR FALL TIME



*HP 212A: Set for 10 μs wide pulses at 2000 pulses per sec. (500 μs intervals). Adjust for I_{B1} = 0.8 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

MJ3040 (SILICON)
thru
MJ3042

Advance Information

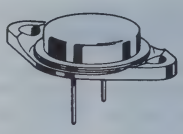
HIGH VOLTAGE SILICON POWER DARLINGTONS

. . . developed for line operated amplifier, series pass and switching regulator applications.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 300 Vdc (Min) – MJ3040, MJ3041
  = 350 Vdc (Min) – MJ3042
- High DC Current Gain –
  h_{FE} = 100 (Min) @ I_C = 2.5 Adc – MJ3040
  = 250 (Min) @ I_C = 2.5 Adc – MJ3041, MJ3042
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 2.2 Vdc (Max) @ I_C = 2.5 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

DARLINGTON
7 AMPERE
POWER TRANSISTORS
NPN SILICON

300, 350 VOLTS
100 WATTS



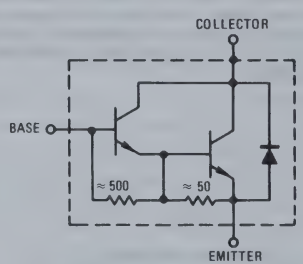
MAXIMUM RATINGS

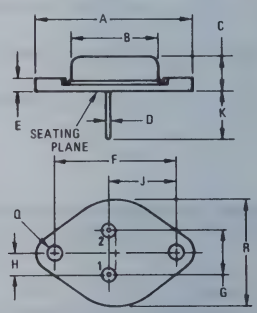
Rating	Symbol	MJ3040	MJ3041	MJ3042	Unit
Collector-Base Voltage	V_{CB}	400	400	500	Vdc
Collector-Emitter Voltage	V_{CEO}	300	300	350	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current – Continuous	I_C	← 7.0 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 100 → ← 0.8 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← -65 to +150 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W

DARLINGTON SCHEMATIC





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.

CASE 11

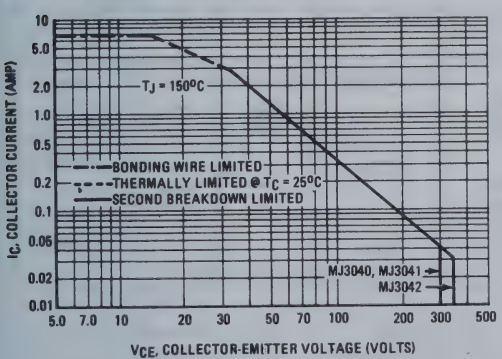
This is advance information on a new introduction and specifications are subject to change without notice.

ADI-193

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	MJ3040, MJ3041	$V_{CEO(sus)}$	300	–	Vdc
	MJ3042		350	–	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 400 Vdc, I_E = 0)	MJ3040, MJ3041		–	1.0	
(V_{CB} = 500 Vdc, I_E = 0)	MJ3042		–	1.0	
(V_{CB} = 400 Vdc, I_E = 0, T_C = 100°C)	MJ3040, MJ3041		–	5.0	
(V_{CB} = 500 Vdc, I_E = 0, T_C = 100°C)	MJ3042		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	20	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	MJ3040		100	–	
	MJ3041, MJ3042		250	–	
(I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	MJ3040		25	–	
	MJ3041, MJ3042		50		
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.5 Adc, I_B = 50 mAdc)			–	2.2	
(I_C = 5.0 Adc, I_B = 400 mAdc)			–	2.5	
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 400 mAdc)		$V_{BE(sat)}$	–	3.0	Vdc
Base-Emitter On Voltage (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	2.5	Vdc

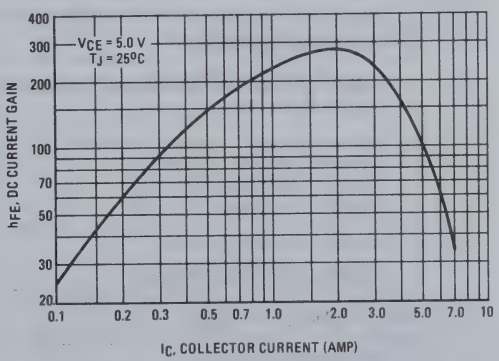
FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor – average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN415).

FIGURE 2 – DC CURRENT GAIN



MJ3101 (SILICON)

For Specifications, See MJ2249 Data.

MJ3201 (SILICON)
MJ3202



CASE 80
(TO-66)

Collector connected to case

High-voltage NPN silicon transistors designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and ac line relays.

MAXIMUM RATINGS

Rating	Symbol	MJ3201	MJ3202	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	225	300	Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current-Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	15 0.1		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 175		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	10	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage [1] (I_C = 1.0 mAdc, I_B = 0)	MJ3201 MJ3202	BV_{CEO}	 225 300	 — —	Vdc
Collector Cutoff Current (V_{CB} = 225 Vdc, I_E = 0) (V_{CB} = 300 Vdc, I_E = 0)	 MJ3201 MJ3202	I_{CBO}	 — —	 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain [1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30	200	—
Collector-Emitter Saturation Voltage [1] (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage [1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	15	—	MHz

[1] Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN

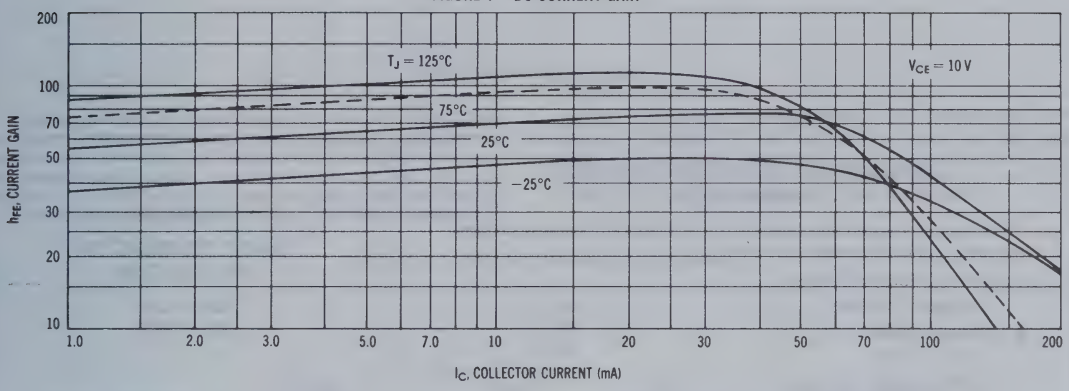


FIGURE 2 — COLLECTOR OUTPUT CHARACTERISTICS

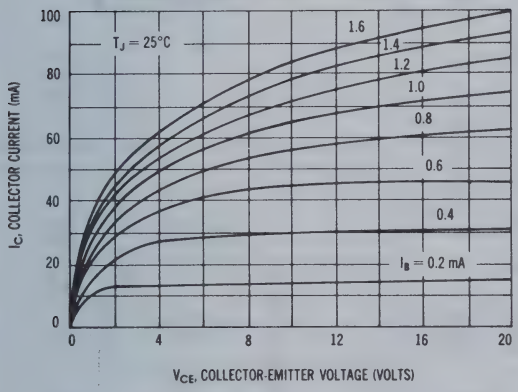


FIGURE 3 — TRANSCONDUCTANCE

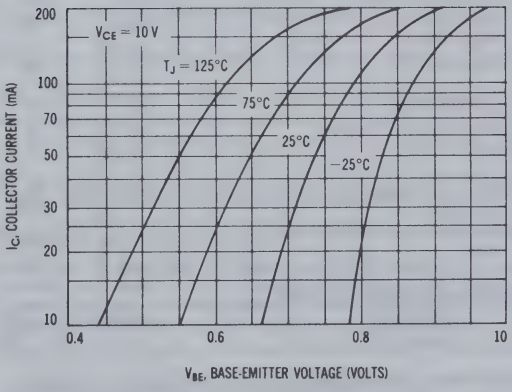


FIGURE 4 — TYPICAL AUDIO AMPLIFIER

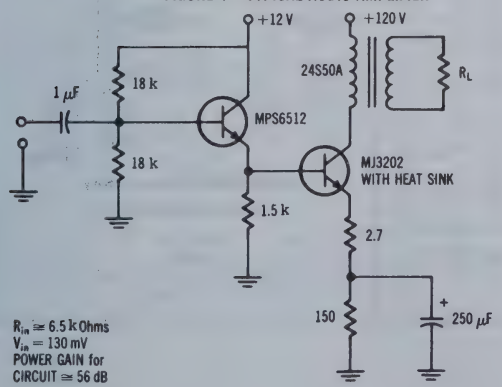
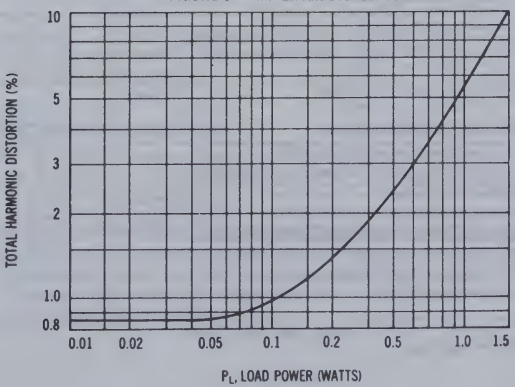


FIGURE 5 — AMPLIFIER DISTORTION



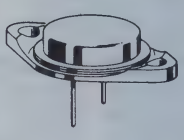
MJ3260 (SILICON)

HORIZONTAL DEFLECTION SILICON TRANSISTOR

. . . designed for use in large screen, 21", 23" and 25" color television receivers, using 90° deflection circuits.

- Collector-Emitter Voltage — V_{CER} = 700 Vdc
- Collector Current — I_C = 6.0 Adc
- Fall Time @ I_C = 5.5 Adc — t_f = 0.4 μs (Typ) = 1.0 μs (Max)
- Circuit Information Included — Complete Technical Dissertation on Requirements for Optimum Circuit Performance

6 AMPERE
POWER TRANSISTOR
NPN SILICON
700 VOLTS
80 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	700	Vdc
Collector-Base Voltage	V_{CB}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	6.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	80 0.64	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150	°C

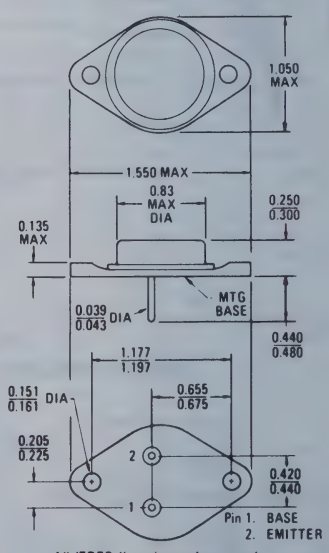
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.56	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	250	–	–	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, V_{BE} = 0)	I_{CES}	–	–	1.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 5.5 Adc, I_B = 1.25 Adc)	$V_{CE(sat)}$	–	–	6.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.5 Adc, I_B = 1.25 Adc)	$V_{BE(sat)}$	–	–	1.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 0.2 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)	f_T	–	7.5	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	–	180	pF
SWITCHING CHARACTERISTICS (Figure 1 and text)					
Fall Time (I_C = 5.5 Adc, I_{B1} = 1.25 Adc, L_B = 2.0 μH) R_B = 1.6 Ohms)	t_f	–	0.4	1.0	μs

(1) Pulse Test: Pulse Width 300 μs, Duty Cycle ≈ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$



All JEDEC dimensions and notes apply

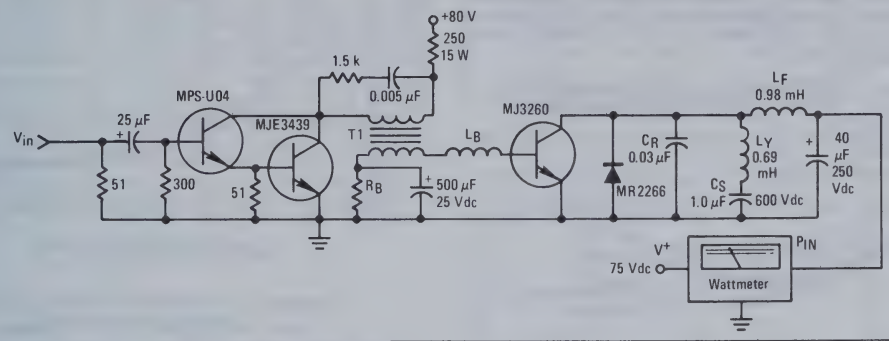
Collector connected to case

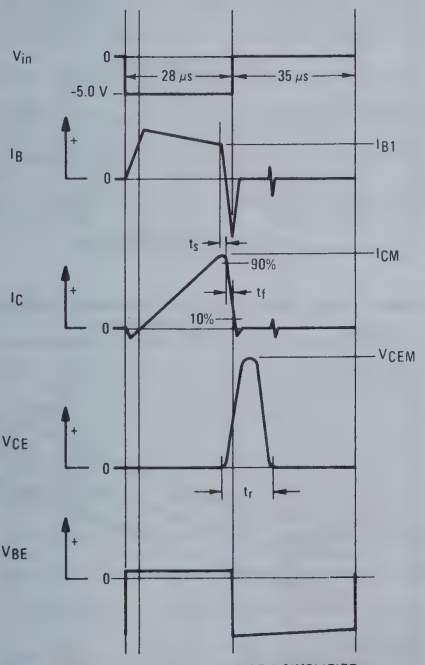
CASE 11
TO-3

CIRCUIT OPTIMIZATION

Test/application circuit and operating waveforms for MJ3260 are shown in Figure 1. It may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, the circuit was designed with operating efficiency in mind, so that it could be used to evaluate devices by one simple criterion, supply power input. Excessive power input can be caused by a variety of problems, but it is the dissipation itself that is of fundamental importance. Once the transistor operating point has been established, fixed circuit values may be selected for the test fixture. Factory testing may then be made with one meter reading, without adjustment of the test apparatus.

FIGURE 1 – TEST CIRCUIT AND WAVEFORMS





FUNDAMENTAL WAVEFORMS OF A SIMPLIFIED HORIZONTAL DEFLECTION CIRCUIT

DESCRIPTION OF SPECIAL COMPONENTS

DUMMY YOKE INDUCTOR (L_Y)

0.69 mH, 36 turns, #16 AWG enamel wire, 12 turns per layer, 3 layers, 1 mil mylar insulation between layers on 1.3 inch plastic bobbin, enclosed in Ferroxcube cup core No. 4229P3B7, core spacing of 0.006 inch.

DUMMY HIGH VOLTAGE AND HORIZONTAL SCAN TRANSFORMER (L_F)

0.98 mH, 31 turns, #12 AWG enamel wire, 16 turns per layer, 1.9 layers, 1 mil mylar insulation between layers on 2.0 inch plastic bobbin, enclosed in a Ferroxcube cup core K5350-11-3E, core spacing of 0.011 inch.

DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance - 39 mH, Secondary Inductance - 0.22 mH, Leakage inductance with primary shorted - 2.0 μH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

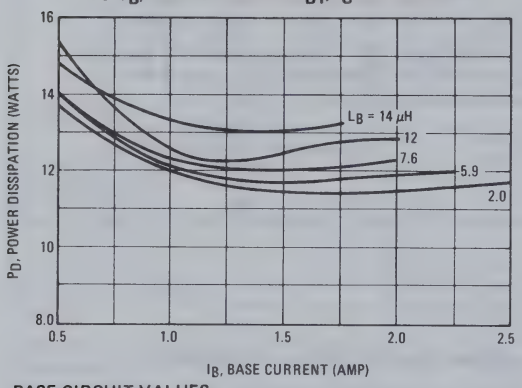
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 1, is one of voltage capability. The flyback voltage to which the device will be subjected is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, (V_{CEM}), shown in Figure 1, will usually be about 8 times the value of V^+, but may be varied somewhat by adjusting retrace time and flyback tuning and can reduce the voltage pulse by 15 to 30% depending on the circuit values chosen.

COLLECTOR CIRCUIT VALUES

The power supply used in the circuit of Figure 1, was chosen to produce a 600 volt collector pulse on the transistor, recommended for regulated applications. The values of yoke (L_Y), flyback primary (L_F), retrace capacitor (C_R), and "S" shaping capacitor (C_S) shown, will result in a peak collector current of about 5.5 A. This is sufficient to deflect (and provide high voltage for) large screen color television receivers using 90° deflection or small and medium-screen color television receivers using 110° deflection. Peak collector currents to 6.0 A may be handled by the MJ3260. Holding the supply constant for most efficient application, adjustment of amount of deflection may be made by raising or lowering L_Y and L_F. Remember that $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 2 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_C = 5.5 A PEAK



BASE CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or Uniwatt type will generally be needed. (The Darlington arrangement of the driver transistors used in Figure 1, produces a wide range of I_{B1} current values). Once the driver circuitry is chosen, the turns ratio of the driver transformer can be picked to produce about 4 to 5 volts peak to peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low ac impedance for good turn-off of the output device. In Figure 2, the effects of varying L_B and I_{B1} on the total power input to the deflection circuit are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 2 is 2.0 μH, which is the leakage inductance value of the driver transformer, and no external L is necessary. A lower L_B would have reduced the power dissipation, over a narrow range of I_{B1}. However, a leakage inductance of 2.0 μH is a minimum practical value. The best value of I_{B1} is 2.0 A achieved in the typical device by using R_B = 1.6 Ω, derived experimentally.

These are the choices recommended for the test fixture, when the transistor is used at I_{CM} = 5.5 A. For other values of I_{CM} the drive circuit components must be changed. Figure 3 shows the values of L_B and I_{B1} which should be used. The value of R_B which will be required to produce the corresponding I_{B1} is also given, but of course, it is not an independent variable.

PERFORMANCE

Shown in Figures 4 and 5 are the results which will be typically obtained with the test circuit at various operating conditions.

FIGURE 3 – INTERRELATION OF R_B, L_B, AND I_{B1}

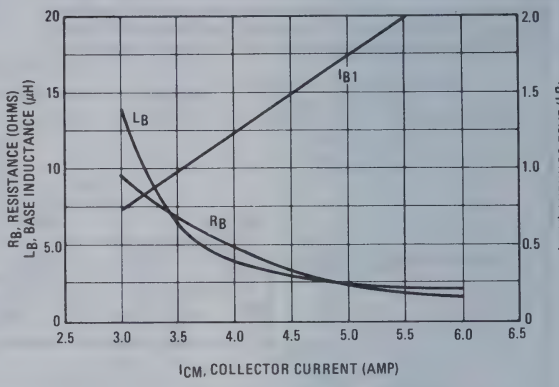


FIGURE 4 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

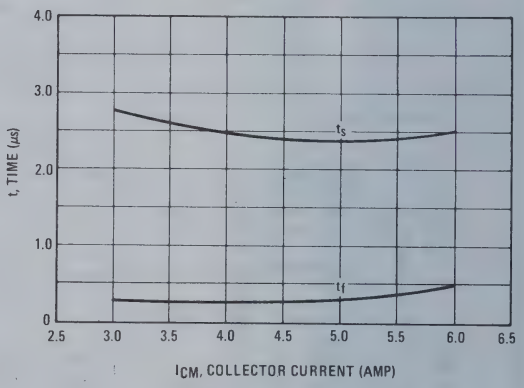
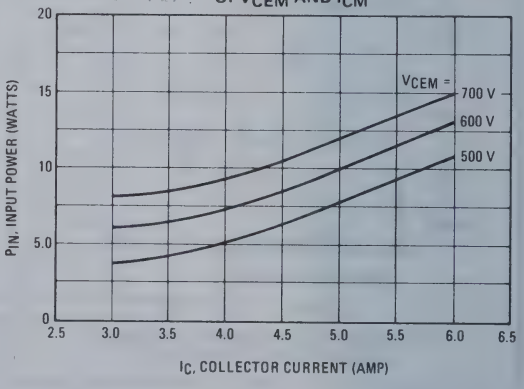


FIGURE 5 – P_{IN}, POWER DISSIPATION WITH DEVIATIONS OF V_{CEM} AND I_{CM}



TYPICAL TRANSISTOR CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

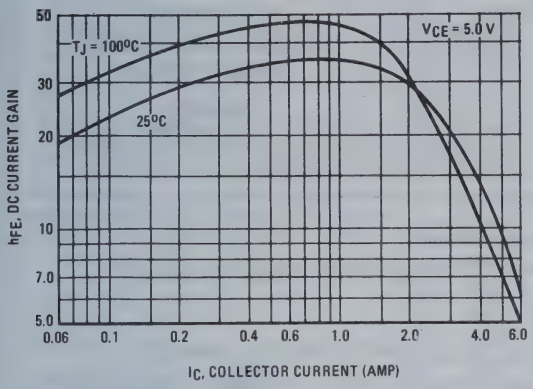


FIGURE 2 – "ON" VOLTAGE

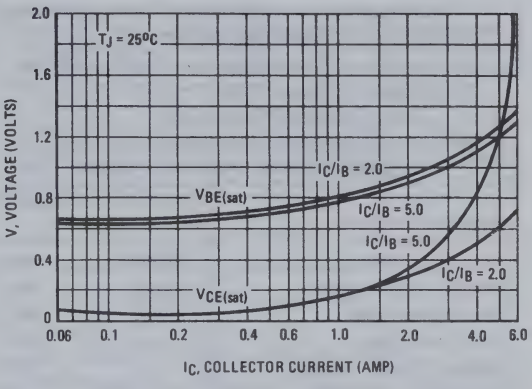
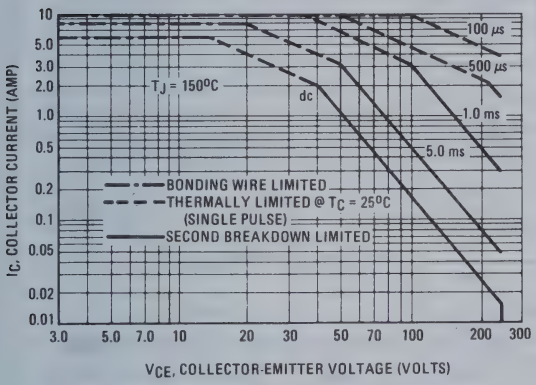


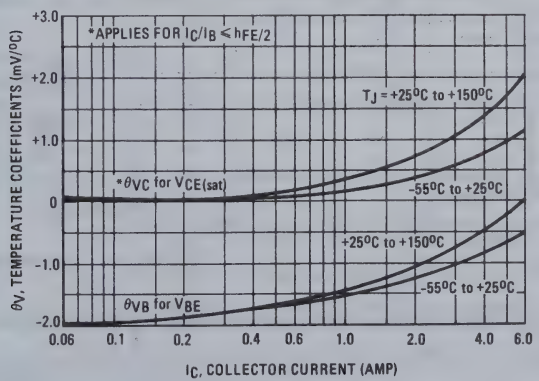
FIGURE 3 – SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 4 – TEMPERATURE COEFFICIENTS



MJ3430 (SILICON)

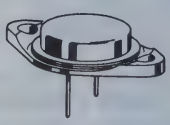
HIGH VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage — V_{CEX} = 400 Vdc
- Excellent DC Current Gain — h_{FE} = 10 (Min) @ I_C = 3.5 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.9 Vdc (Max) @ I_C = 2.5 Adc

5.0 AMPERE
POWER TRANSISTOR
NPN SILICON

300 VOLTS
125 WATTS



MAXIMUM RATINGS

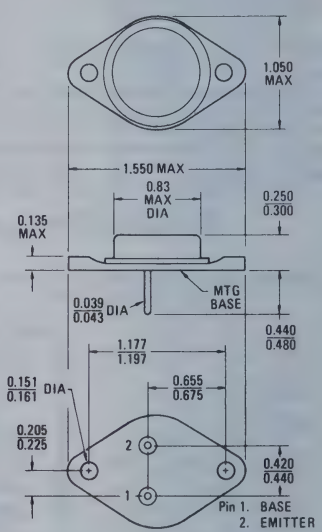
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	5.0	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	—	Vdc
Collector Cutoff Current (V_{CE} = 300 Vdc, I_B = 0)	I_{CEO}	—	2.5	mAdc
Collector Cutoff Current (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	I_{CEX}	— —	1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc) (I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15 10	45 —	—
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 0.5 Adc)	$V_{CE(sat)}$	—	0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 0.5 Adc)	$V_{BE(sat)}$	—	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 10 Vdc)	f_T	2.5	—	MHz

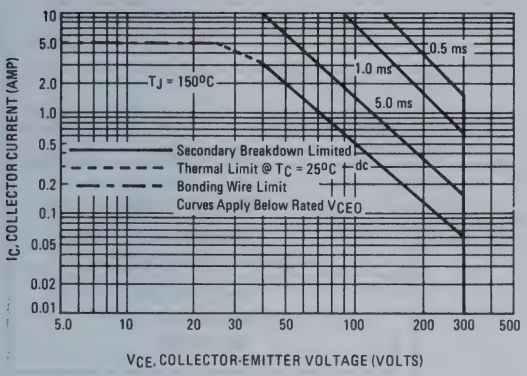


All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

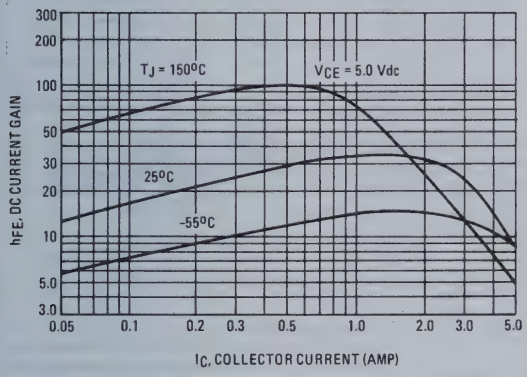


FIGURE 3 – "ON" VOLTAGES

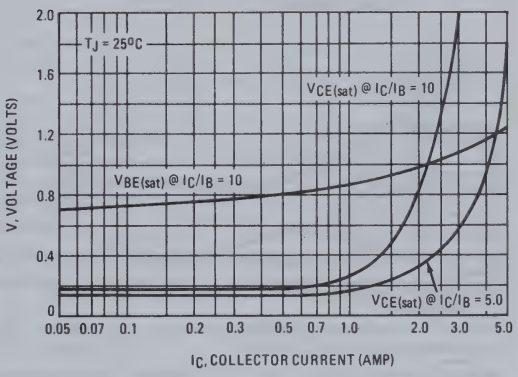


FIGURE 4 – SUSTAINING VOLTAGE TEST LOAD LINE

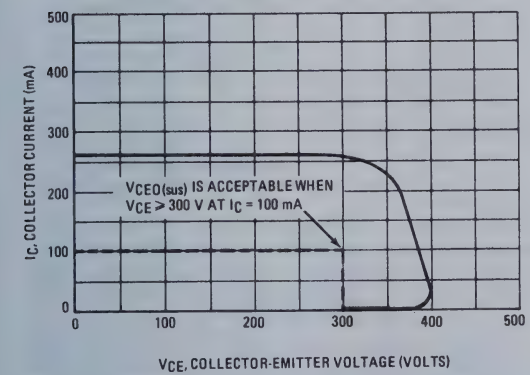
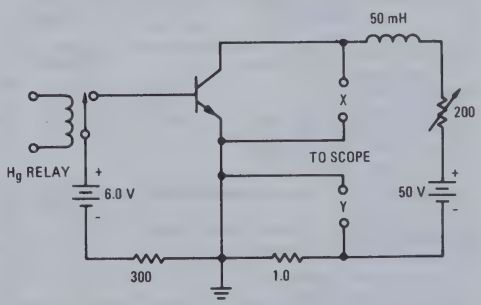


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ3480 (SILICON)

For Specifications, See BU108 Data.

MJ3520 (SILICON)

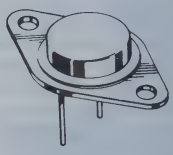
NPN SILICON POWER DARLINGTON TRANSISTOR

Uni Base (single-diffused) transistor designed for series pass regulators, audio amplifiers and for use in inductive power control circuitry.

- DC Current Gain —
  h_{FE} = 500 (Min) @ I_C = 4.0 Adc
  = 100 (Min) @ I_C = 10 Adc
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 2.5 Vdc (Max) @ I_C = 4.0 Adc
  = 4.0 Vdc (Max) @ I_C = 10 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

UNIBASE

DARLINGTON
15 AMPERE
POWER TRANSISTOR
NPN SILICON
40 VOLTS
150 WATTS



MAXIMUM RATINGS

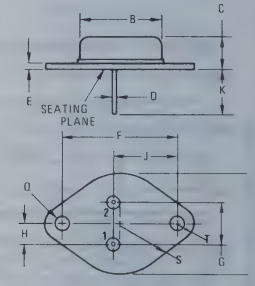
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous Peak	I_C	15 30	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	150 1.20	~~Watts~~ W °C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.833	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	5.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	2.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 10 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	500 100	– –	–
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 32 mAdc) (I_C = 10 Adc, I_B = 200 mAdc)	$V_{CE(sat)}$	– –	2.5 4.0	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	3.0	Vdc
DYNAMIC CHARACTERISTICS				
Magnitude of Common-Emitter Small-Signal Short-Circuit Current Transfer Ratio (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f_{test} = 50 kHz)	$\lvert h_{fe} \rvert$	4.0	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	600	pF
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	300	–	–



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

STYLE 2:
PIN 1. BASE
2. COLLECTOR
CASE-EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S		13.34		0.525
T		4.78		0.188

All JEDEC dimensions and notes apply.

CASE 1-03
(TO-3)

FIGURE 1 – DC CURRENT GAIN

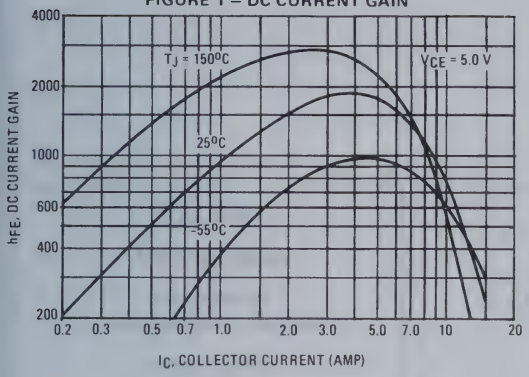


FIGURE 2 – COLLECTOR SATURATION REGION

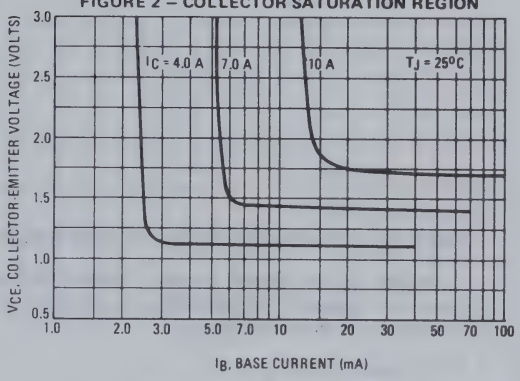


FIGURE 3 – "ON" VOLTAGES

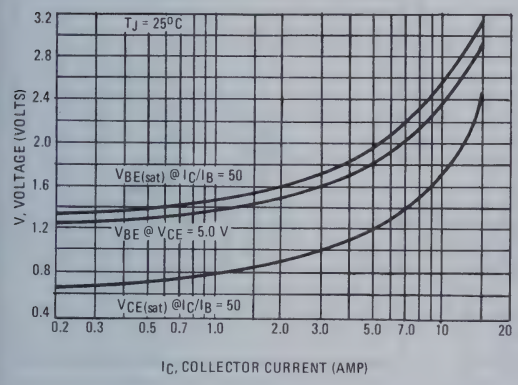


FIGURE 4 – TEMPERATURE COEFFICIENTS

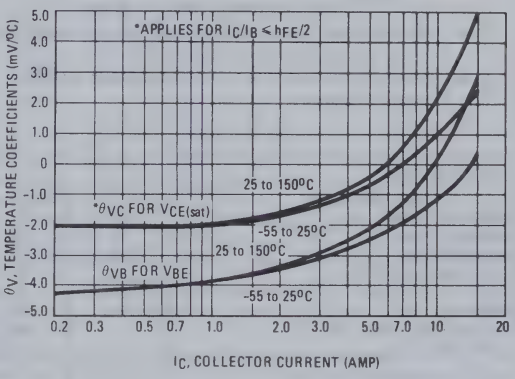


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

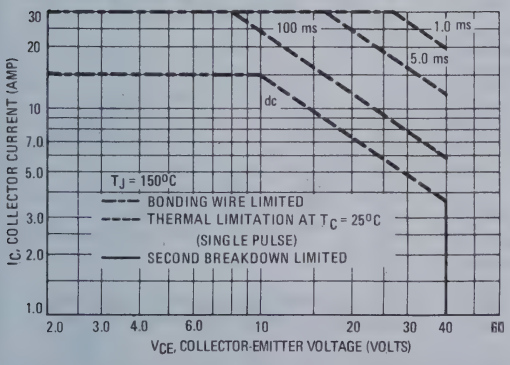
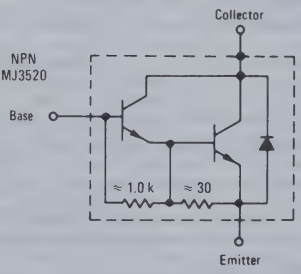


FIGURE 6 – DARLINGTON SCHEMATIC



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJ3521 (SILICON)

NPN SILICON POWER DARLINGTON TRANSISTOR

Unibase (single diffused) transistor designed for series pass regulators, and power switching applications, audio amplifiers and for use in inductive power control circuitry.

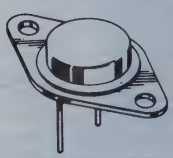
- DC Current Gain –
  h_{FE} = 500 (Min) @ I_C = 4.0 Adc
  = 100 (Min) @ I_C = 15 Adc
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.8 Vdc (Max) @ I_C = 4.0 Adc
  = 4.0 Vdc (Max) @ I_C = 15 Adc
- Forward Biased Second Breakdown Energy Capability –
  $I_{S/b}$ = 1.4 Adc @ V_{CE} = 80 Vdc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

UNIBASE

DARLINGTON

15 AMPERE POWER TRANSISTOR

NPN SILICON
80 VOLTS
150 WATTS



MAXIMUM RATINGS

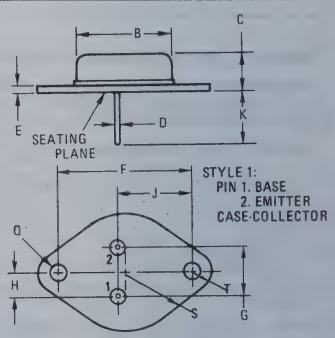
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous Peak	I_C	15 30	Adc
Base Current	I_B	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	150 1.20	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.833	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	80	–	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0)	I_{CEO}	–	1.0	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	2.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 15 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	500 100	– –	–
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 16 mAdc) (I_C = 15 Adc, I_B = 300 mAdc)	$V_{CE(sat)}$	– –	1.8 4.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	–	3.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	3.0	Vdc
DYNAMIC CHARACTERISTICS				
Magnitude of Common-Emitter Small-Signal Short-Circuit Current Transfer Ratio (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f_{test} = 50 kHz)	$\|h_{fe}\|$	4.0	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	600	pF
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	300	–	–



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	—	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0.188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

FIGURE 1 – DC CURRENT GAIN

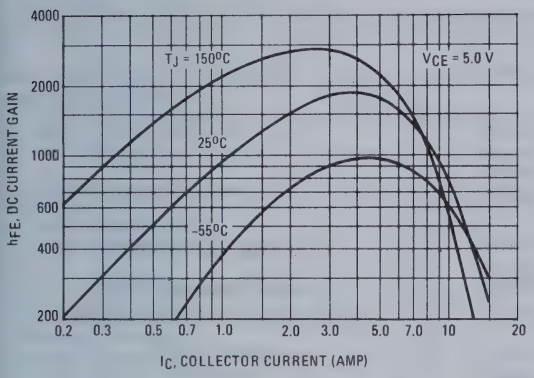


FIGURE 2 – COLLECTOR SATURATION REGION

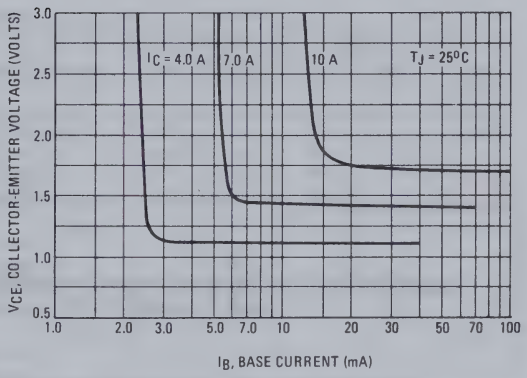


FIGURE 3 – "ON" VOLTAGES

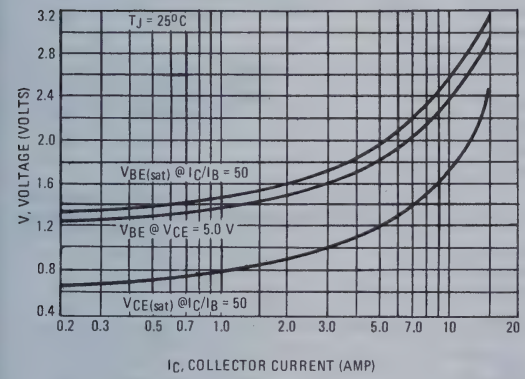


FIGURE 4 – TEMPERATURE COEFFICIENTS

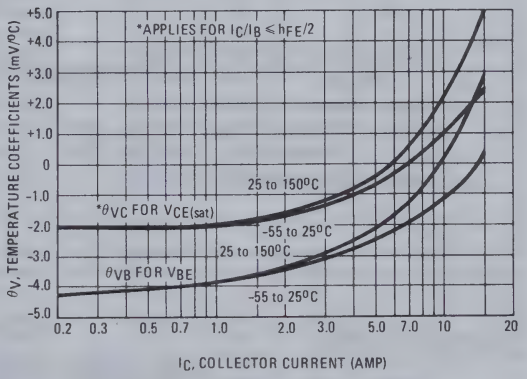


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA

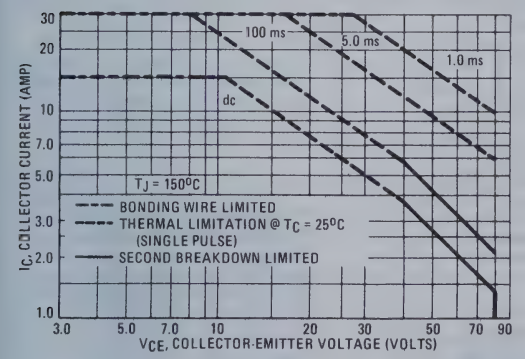
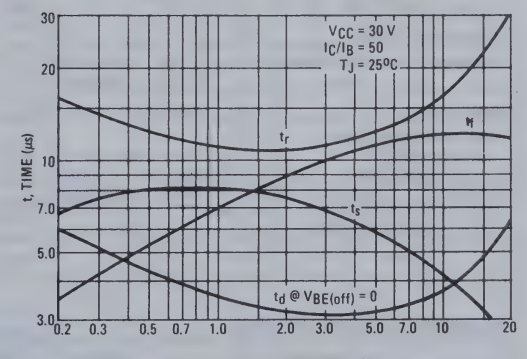


FIGURE 6 – SWITCHING TIMES



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJ3583 thru MJ3585, MJ4240 PNP (SILICON)
2N3583 thru 2N3585, 2N4240 NPN

COMPLEMENTARY MEDIUM-POWER HIGH VOLTAGE POWER TRANSISTORS

. . . designed for high-speed switching and linear amplifier applications for high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

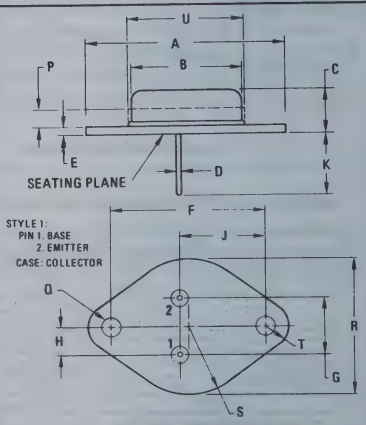
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 175 to 300 Vdc @ I_C = 200 mAdc
- Second Breakdown Collector Current –
  $I_{s/b}$ = 350 mAdc @ V_{CE} = 100 Vdc – NPN
  = 150 mAdc @ V_{CE} = 100 Vdc – PNP
- Usable DC Current Gain to 2.0 Adc

1.0 AND 2.0 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

250-500 VOLTS
35 WATTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

***MAXIMUM RATINGS**

Rating	Symbol	2N3583 MJ3583	2N3584 MJ3584	2N3585 MJ3585	2N4240 MJ4240	Unit
Collector-Emitter Voltage	V_{CEO}	175	250	300	300	Vdc
Collector-Base Voltage	V_{CB}	250	375	500	500	Vdc
Emitter-Base Voltage	V_{EB}	6.0				Vdc
Collector Current – Continuous	I_C	1.0	2.0			Adc
– Peak		5.0	5.0			
Base Current	I_B	1.0				Adc
Total Device Dissipation @ T_C = 25°C,	P_D	35				Watts
Derate above 25°C		0.2				W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	°C/W

*Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN Min	NPN Max	PNP Min	PNP Max	Unit
***OFF CHARACTERISTICS**								
Collector-Emitter Sustaining Voltage	2N3583	MJ3583	$V_{CEO(sus)}$	175	–	175	–	Vdc
(I_C = 200 mAdc, I_B = 0) NPN	2N3584	MJ3584		250	–	250	–	
	2N3585	MJ3585		300	–	300	–	
(I_C = 50 mAdc, I_B = 0) PNP	2N4240	MJ4240		300	–	300	–	
Collector Cutoff Current			I_{CEO}					mAdc
(V_{CE} = 150 Vdc, I_B = 0)	2N3583	MJ3583		–	10	–	10	
	2N3584	MJ3584		–	5.0	–	5.0	
	2N3585	MJ3585		–	5.0	–	5.0	
	2N4240	MJ4240		–	5.0	–	5.0	
Collector Cutoff Current			I_{CEX}					mAdc
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3583	MJ3583		–	1.0	–	1.0	
(V_{CE} = 340 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3584	MJ3584		–	1.0	–	1.0	
(V_{CE} = 450 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3585	MJ3585		–	1.0	–	1.0	
	2N4240	MJ4240		–	2.0	–	2.0	
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3583	MJ3583		–	3.0	–	3.0	
(V_{CE} = 300 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3584	MJ3584		–	3.0	–	3.0	
	2N3585	MJ3585		–	3.0	–	3.0	
	2N4240	MJ4240		–	5.0	–	5.0	
Emitter Cutoff Current			I_{EBO}					mAdc
(V_{BE} = 6.0 Vdc, I_C = 0)	2N3583	MJ3583		–	5.0	–	5.0	
	2N3584	MJ3584		–	0.5	–	0.5	
	2N3585	MJ3585		–	0.5	–	0.5	
	2N4240	MJ4240		–	0.5	–	0.5	
ON CHARACTERISTICS								
DC Current Gain			h_{FE}					–
(I_C = 0.1 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		40	–	40	–	
	2N3584	MJ3584		40	–	40	–	
	2N3585	MJ3585		40	–	40	–	
	2N4240	MJ4240		40	–	40	–	
*(I_C = 0.5 Adc, V_{CE} = 10 Vdc)	2N3583	MJ3583		40	200	40	200	
*(I_C = 0.75 Adc, V_{CE} = 2.0 Vdc)	2N4240	MJ4240		10	100	10	100	
(I_C = 0.75 Adc, V_{CE} = 10 Vdc)	2N4240	MJ4240		30	150	30	150	
*(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	2N3584	MJ3584		8.0	80	8.0	80	
	2N3585	MJ3585		8.0	80	8.0	80	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		10	–	10	–	
	2N3584	MJ3584		25	100	25	100	
	2N3585	MJ3585		25	100	25	100	
*Collector-Emitter Saturation Voltage			$V_{CE(sat)}$					Vdc
(I_C = 0.75 Adc, I_B = 75 mAdc)	2N4240	MJ4240		–	1.0	–	1.0	
(I_C = 1.0 Adc, I_B = 125 mAdc)	2N3583	MJ3583		–	5.0	–	5.0	
	2N3584	MJ3584		–	0.75	–	0.75	
	2N3585	MJ3585		–	0.75	–	0.75	
*Base-Emitter Saturation Voltage			$V_{BE(sat)}$					Vdc
(I_C = 0.75 Adc, I_B = 75 mAdc)	2N4240	MJ4240		–	1.8	–	1.8	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3584	MJ3584		–	1.4	–	1.4	
	2N3585	MJ3585		–	1.4	–	1.4	
Base-Emitter On Voltage			$V_{BE(on)}$					Vdc
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		–	1.4	–	1.4	
	2N3584	MJ3584		–	1.4	–	1.4	
	2N3585	MJ3585		–	1.4	–	1.4	
	2N4240	MJ4240		–	1.4	–	1.4	

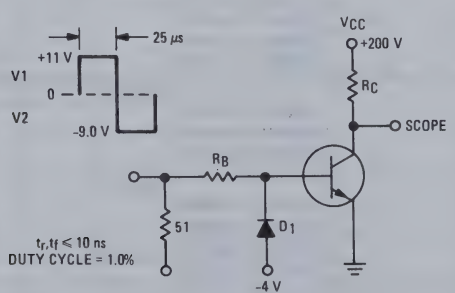
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN Min	NPN Max	PNP Min	PNP Max	Unit
DYNAMIC CHARACTERISTICS								
*Current Gain – Bandwidth Product[1] (I_C = 200 mAdc, V_{CE} = 10 Vdc, f_{test} = 5.0 MHz)	2N3583 2N3584 2N3585 2N4240	MJ3583 MJ3584 MJ3585 MJ4240	f_T	10 15	–	10 15	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	All	All	C_{ob}	–	120	–	120	pF
*Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 30 Vdc, f = 1.0 kHz)	2N3583	MJ3583	h_{fe}	25	350	25	350	–
***SWITCHING CHARACTERISTICS**								
Rise Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, R_L = 200 Ohms, I_{B1} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, R_L = 267 Ohms, I_{B1} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_r	– –	3.0 0.5	– –	3.0 0.5	μs
Storage Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, I_{B1} = I_{B2} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_s	– –	4.0 6.0	– –	4.0 6.0	μs
Fall Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, I_{B1} = I_{B2} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_f	– –	3.0 3.0	– –	3.0 3.0	μs
Second Breakdown Collector Current (V_{CE} = 100 Vdc)	All	All	$I_{s/b}$	350	–	150	–	mAdc

*Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

(1) $f_T = |h_{fe}| \bullet f_{test}$.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS
D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx$ 100 mA
MSD6100 USED BELOW $I_B \approx$ 100 mA
FOR t_d and t_r, D1 IS DISCONNECTED AND V_2 = 0.
FOR PNP TEST CIRCUIT, REVERSE DIODE AND VOLTAGE POLARITIES.

NPN
2N3583 thru 2N3585,2N4240

PNP
MJ3583 thru MJ3585,MJ4240

FIGURE 2 – TURN-ON TIME

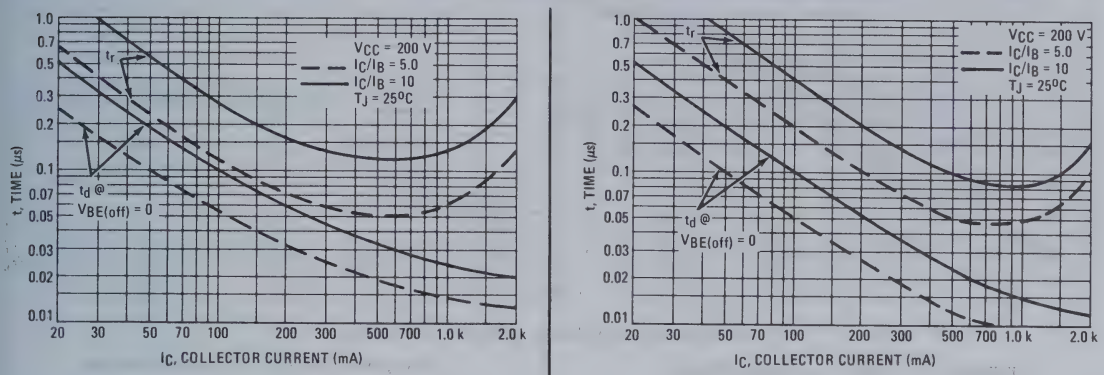


FIGURE 3 – TURN-OFF TIME

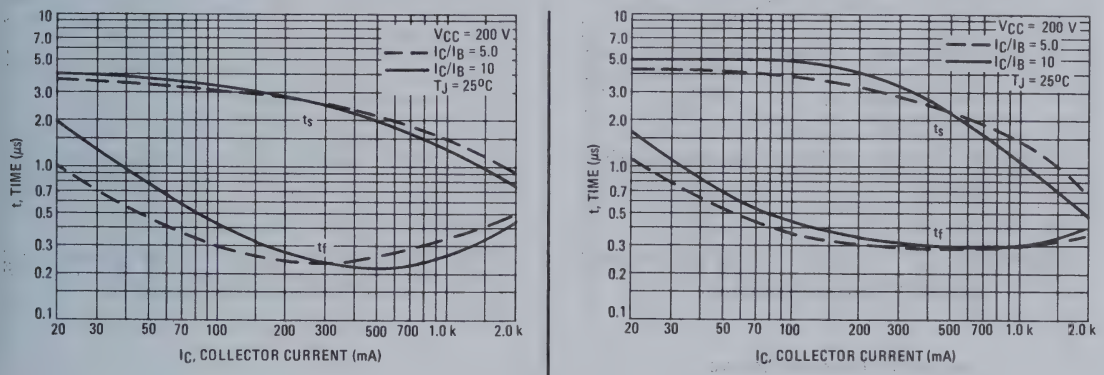


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

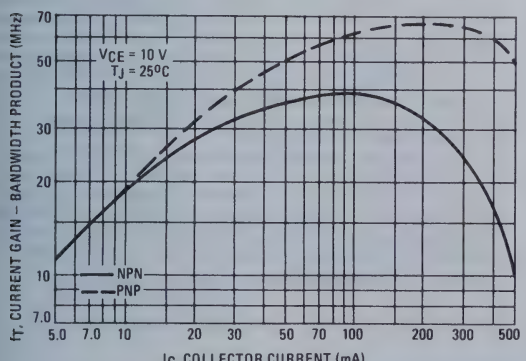


FIGURE 5 – CAPACITANCE

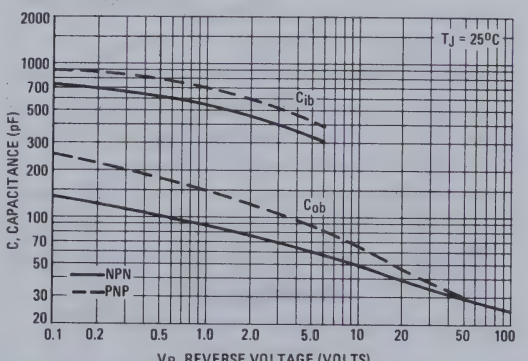
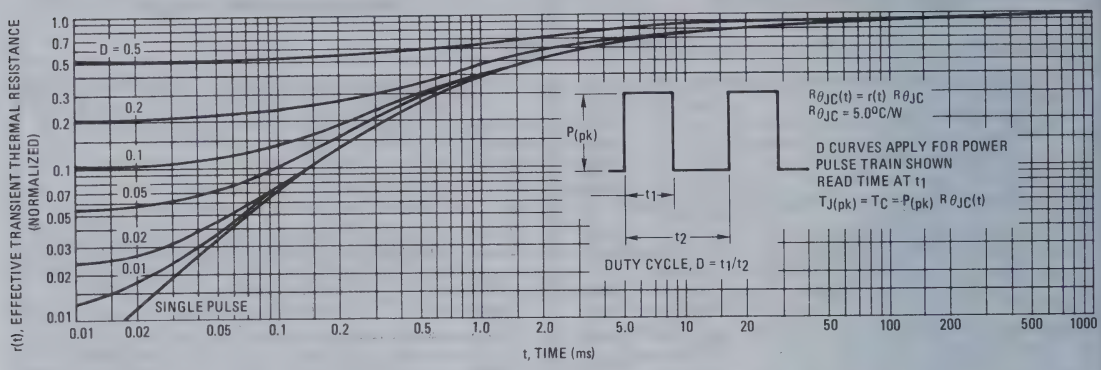


FIGURE 6 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 7 – 2N3583 thru 2N3585, 2N4240

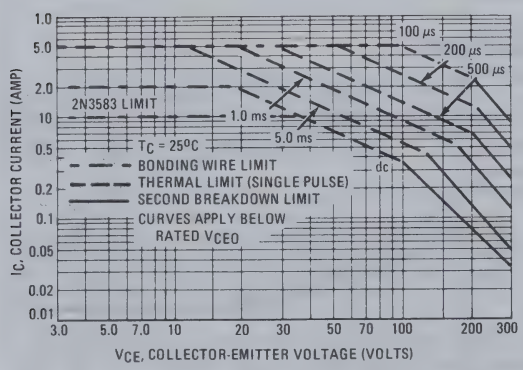


FIGURE 8 – MJ3583 thru MJ3585, MJ4240

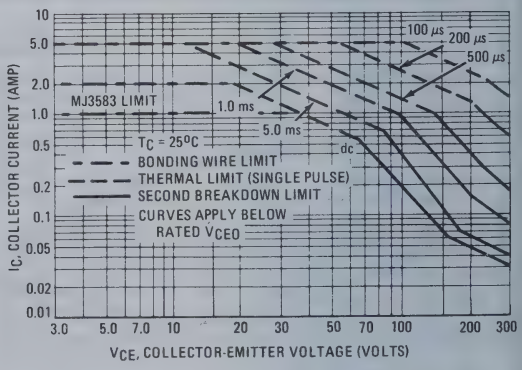
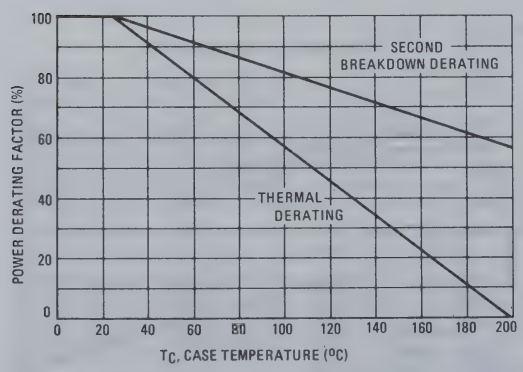


FIGURE 9 – POWER DERATING



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 7 and 8 is based on $T_C = 25^oC$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 9.

$T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 7 and 8 may be found at any case temperature by using the appropriate curve on Figure 9.

NPN
2N3583 thru 2N3585,2N4240

PNP
MJ3583 thru MJ3585,MJ4240

FIGURE 10 – DC CURRENT GAIN

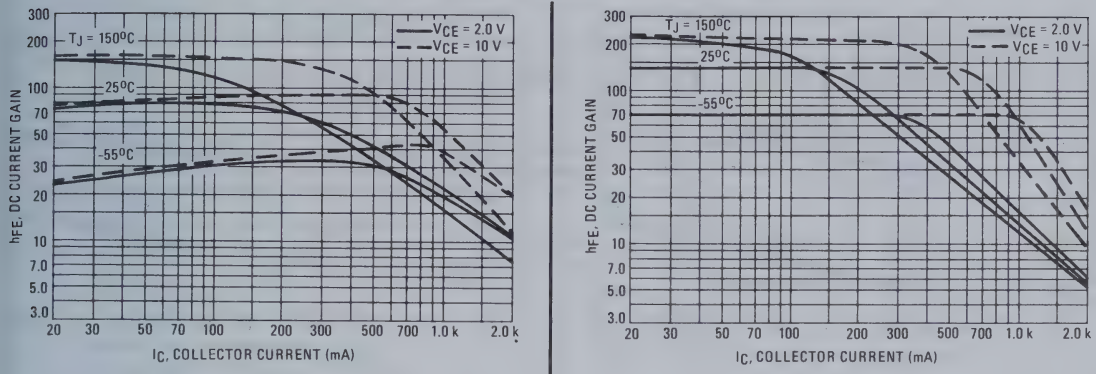


FIGURE 11 – COLLECTOR SATURATION REGION

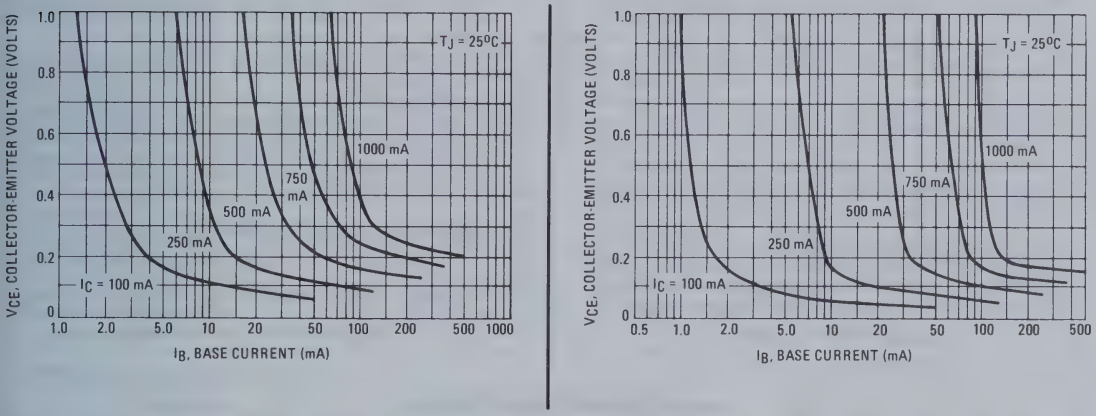
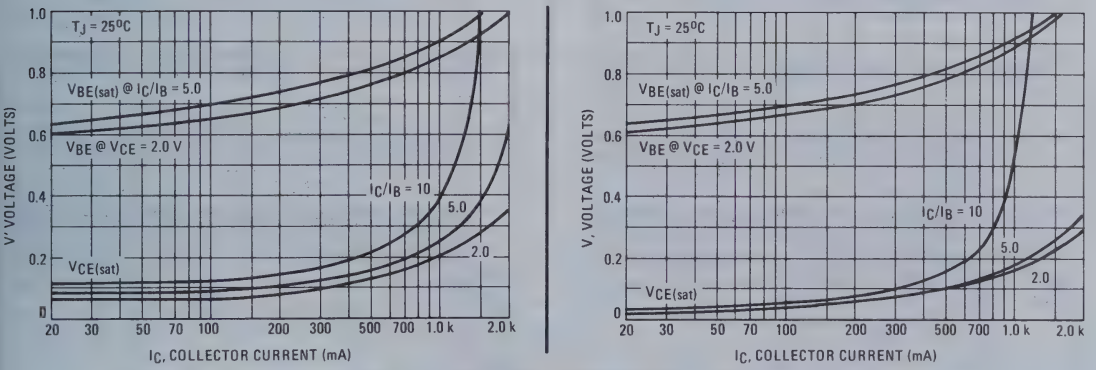


FIGURE 12 – "ON" VOLTAGES

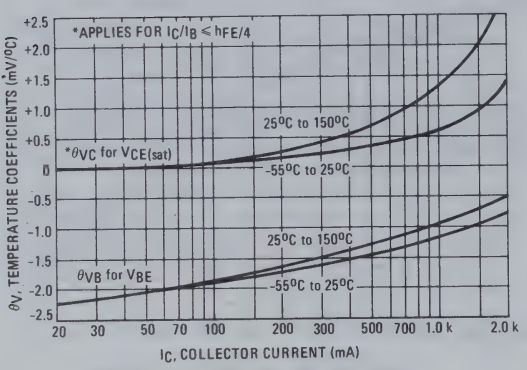


NOTE: DC CURRENT LIMIT FOR 2N3583, MJ3583 is 1.0 Amp.

NPN
2N3583 thru 2N3585,2N4240

PNP
MJ3583 thru MJ3585,MJ4240

FIGURE 13 – TEMPERATURE COEFFICIENTS



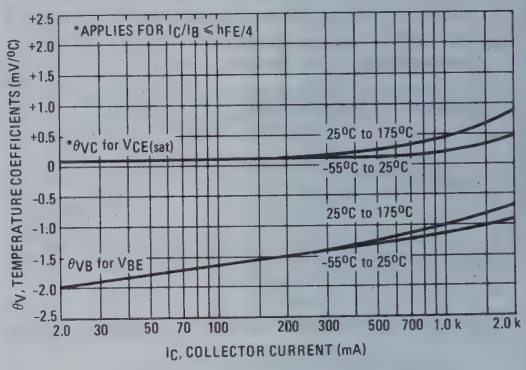
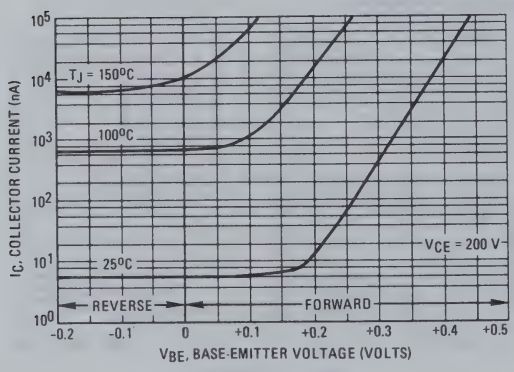


FIGURE 14 – COLLECTOR CUTOFF REGION



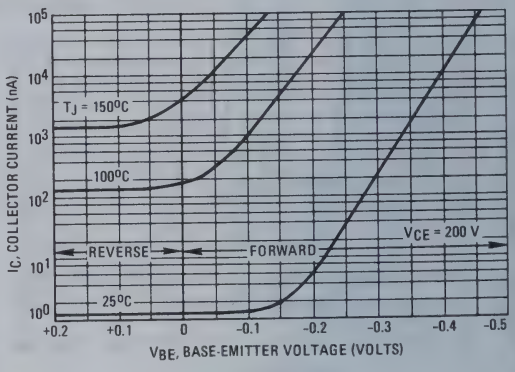
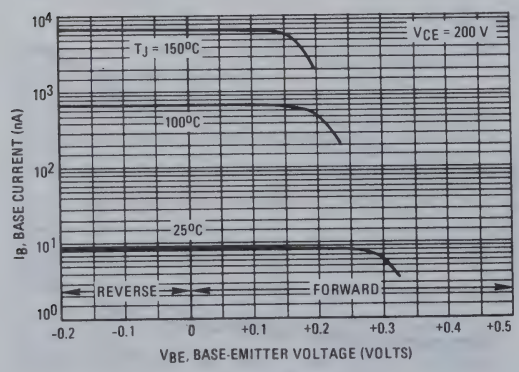
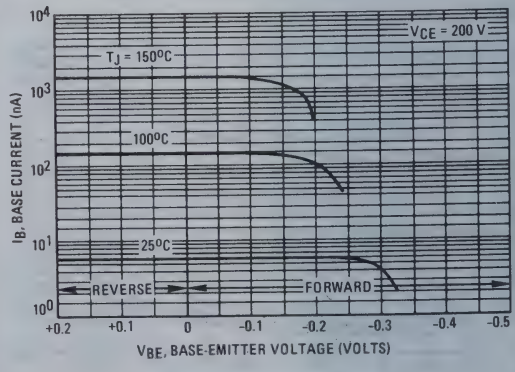


FIGURE 15 – BASE CUTOFF REGION





MJ3738, MJ3739 PNP (SILICON)
2N3738, 2N3739 NPN

HIGH VOLTAGE COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for high-speed switching, linear amplifier applications, high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 225 Vdc @ I_C = 5.0 mAdc (2N3738, MJ3738)
  = 300 Vdc @ I_C = 5.0 mAdc (2N3739, MJ3739)
- DC Current Gain –
  h_{FE} = 40-200 @ I_C = 100 mAdc
- Current-Gain – Bandwidth Product –
  f_T = 10 MHz (Min) @ I_C = 100 mAdc
- $I_{S/b}$ Rated to 2.0 Amperes

2.0 AMPERE
POWER TRANSISTORS COMPLEMENTARY SILICON
225, 300 VOLTS
20 WATTS



*MAXIMUM RATINGS

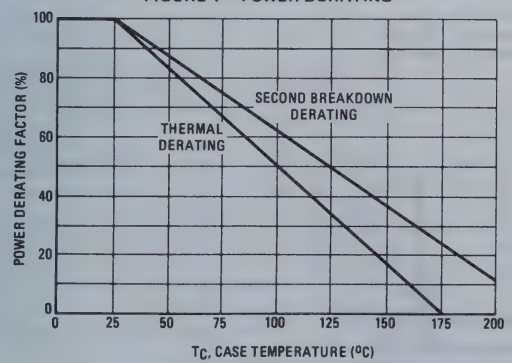
Rating	Symbol	2N3738 MJ3738	2N3739 MJ3739	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous – Peak	I_C	0.25 2.0		Adc
Base Current – Continuous – Peak	I_B	0.50 1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.133		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +175		°C

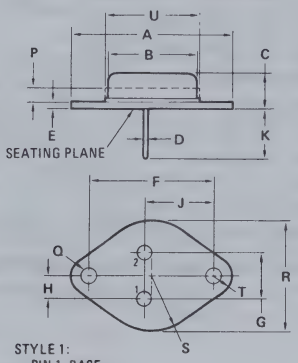
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.5	°C/W

*Indicates JEDEC Registered Data for 2N3738 and 2N3739.

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

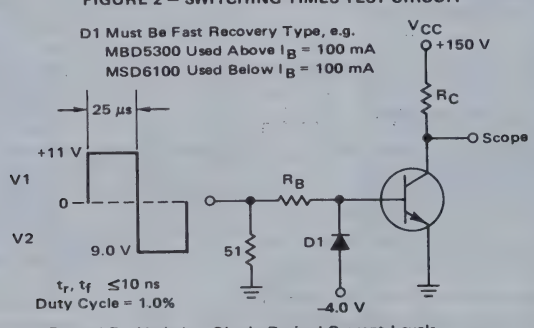
Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1) (I_C = 5.0 mAdc, I_B = 0)	2N3738,MJ3738	$V_{CEO(sus)}$	225	–	Vdc
	2N3739,MJ3739		300	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 125 Vdc, I_B = 0)	2N3738,MJ3738		–	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	2N3739,MJ3739		–	0.25	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 250 Vdc, I_E = 0)	2N3738,MJ3738		–	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	2N3739,MJ3739		–	0.1	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3738,MJ3738		–	0.5	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3739,MJ3739		–	0.5	
(V_{CE} = 125 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N3738,MJ3738		–	1.0	
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N3739,MJ3739		–	1.0	
Emitter-Base Cutoff Current (V_{EB} = 6.0 Vdc)		I_{EBO}	–	0.1	mAdc
***ON CHARACTERISTICS**					
DC Current Gain (1)		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			40	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			25	–	
Collector-Emitter Saturation Voltage (1) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	–	2.5	Vdc
Base-Emitter "ON" Voltage (1) (I_C = 100 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	10	–	MHz
*Output Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	pF
*Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)		h_{fe}	35	–	–

*Indicates JEDEC Registered Data for 2N3738 and 2N3739.

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2%.

(2) $f_T = |h_{fe}| \cdot$ frequency

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



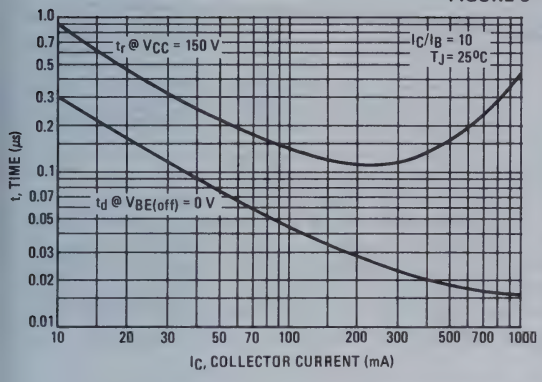
R_B and R_C Varied to Obtain Desired Current Levels

For t_d and t_r, D1 is disconnected and V2 = 0
For PNP test circuit, reverse diode and voltage polarities.

NPN
2N3738, 2N3739

PNP
MJ3738, MJ3739

FIGURE 3 – TURN-ON TIME



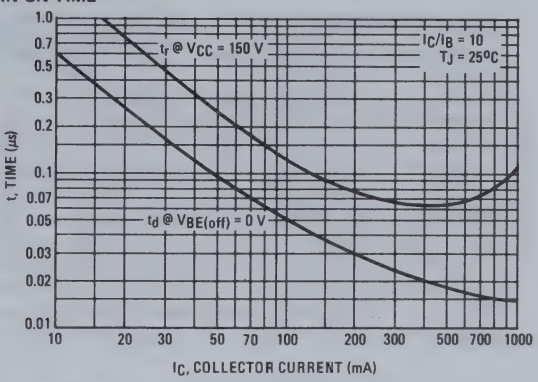
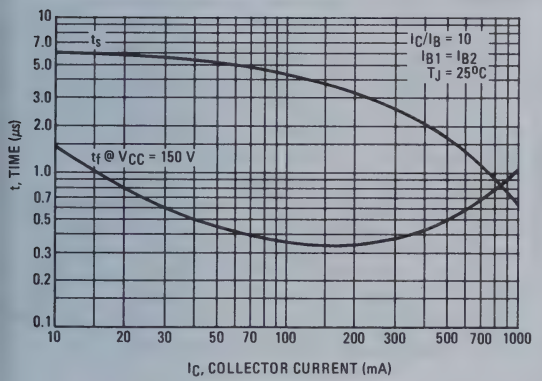


FIGURE 4 – TURN-OFF TIME



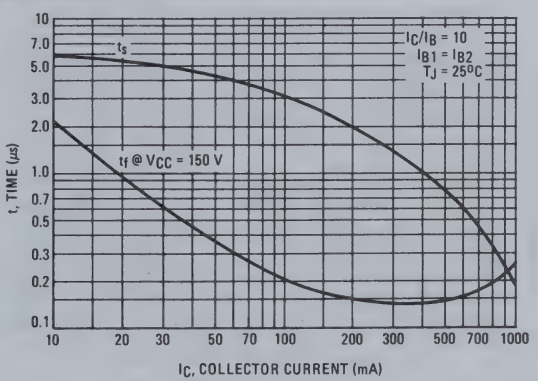


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

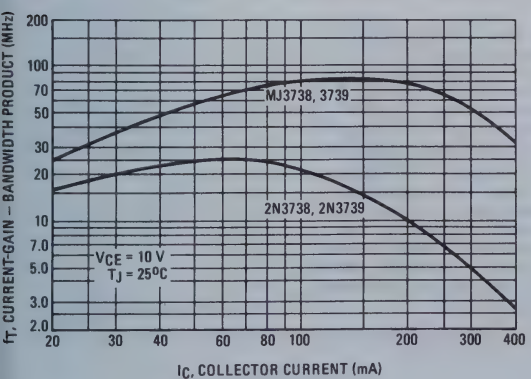


FIGURE 6 – CAPACITANCE

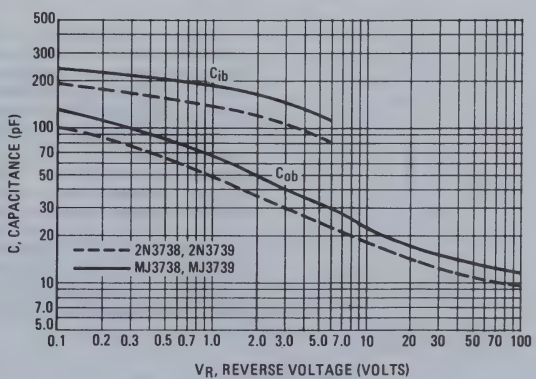
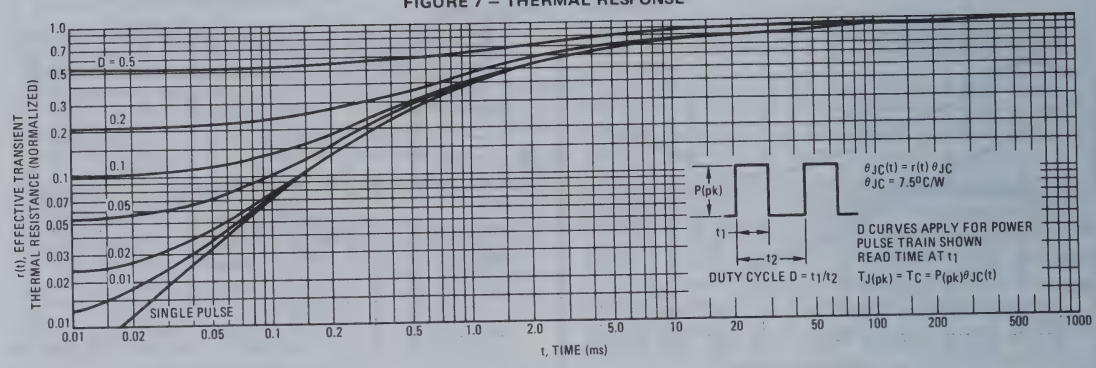


FIGURE 7 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 8 – 2N3738, 2N3739

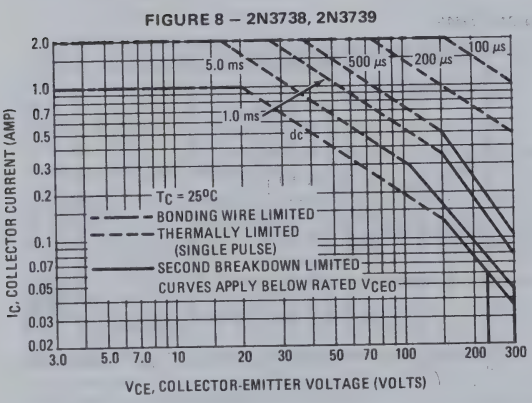
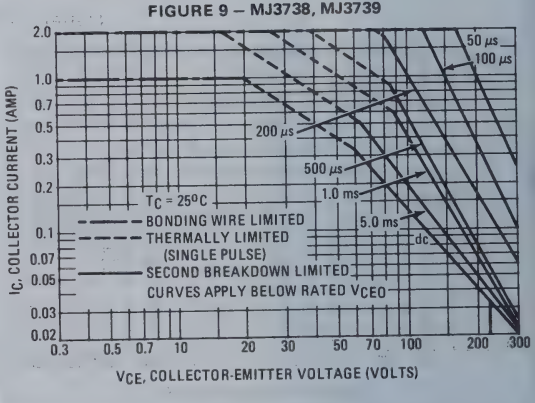


FIGURE 9 – MJ3738, MJ3739



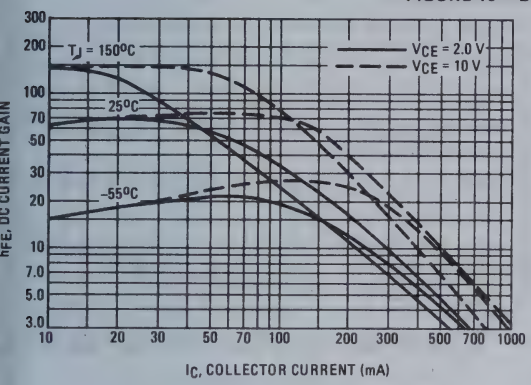
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 8 and 9 is based on $T_C = 25^oC$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 175^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 8 and 9 may be found at any case temperature by using the appropriate curve on Figure 1.

NPN
2N3738, 2N3739

PNP
MJ3738, MJ3739

FIGURE 10 – DC CURRENT GAIN



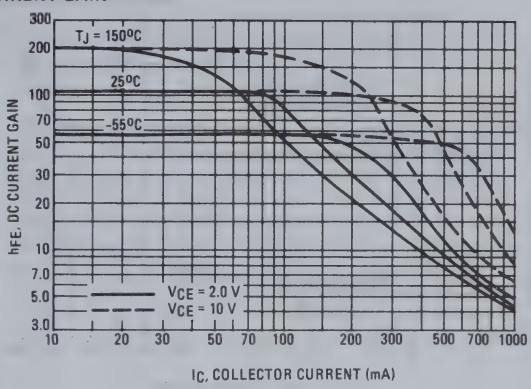
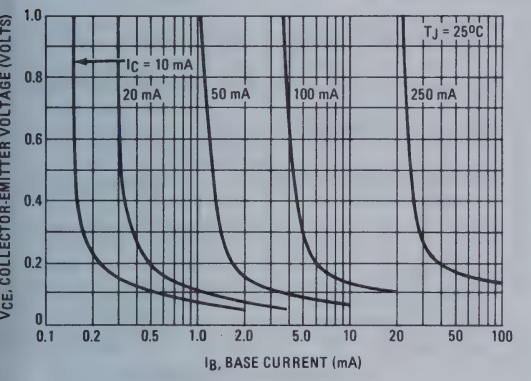


FIGURE 11 – COLLECTOR SATURATION REGION



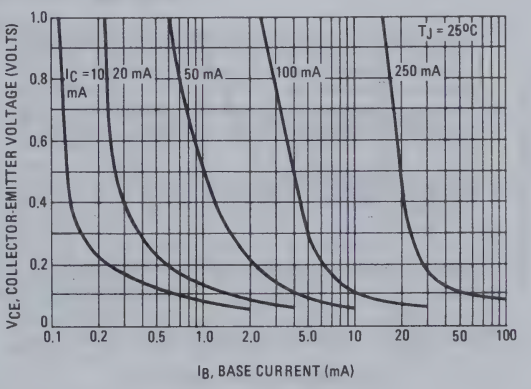
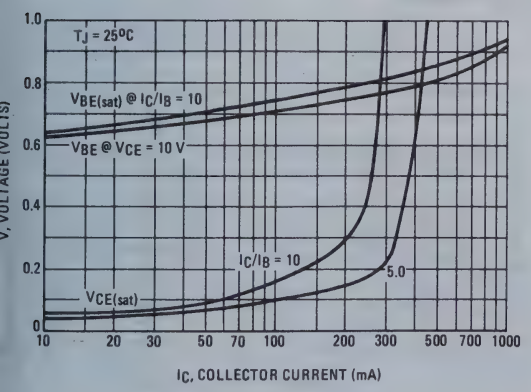
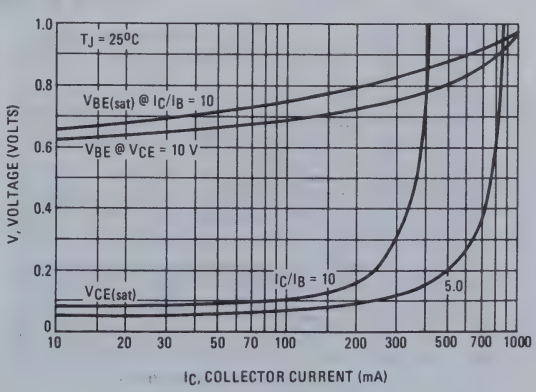


FIGURE 12 – "ON" VOLTAGE

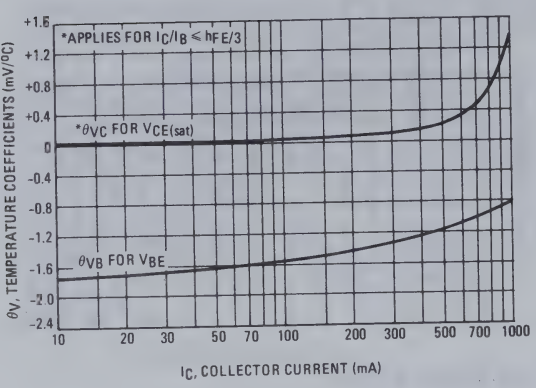




NPN
2N3738, 2N3739

PNP
MJ3738, MJ3739

FIGURE 13 – TEMPERATURE COEFFICIENTS



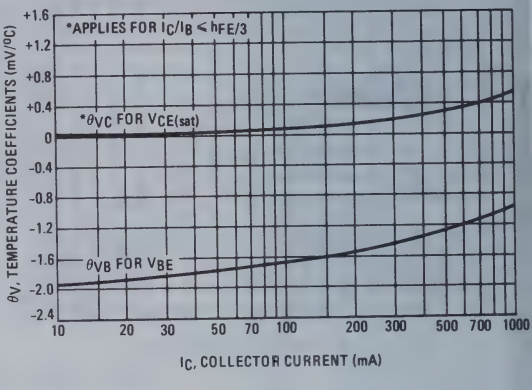
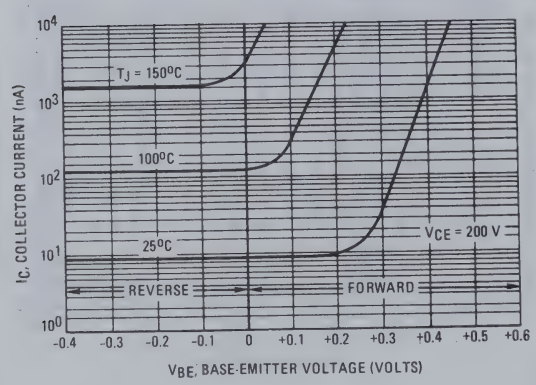


FIGURE 14 – COLLECTOR CUTOFF REGION



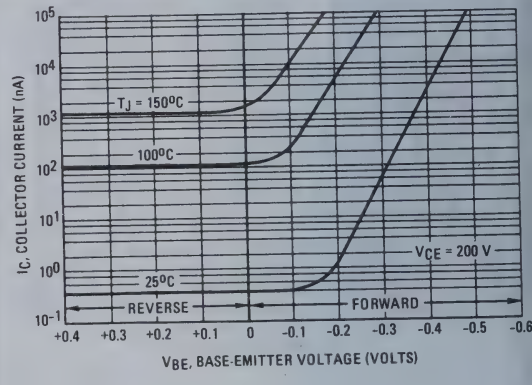
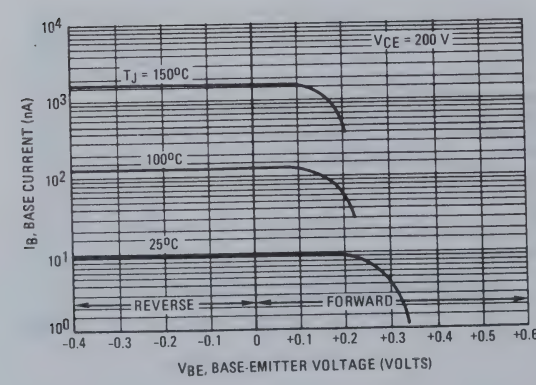
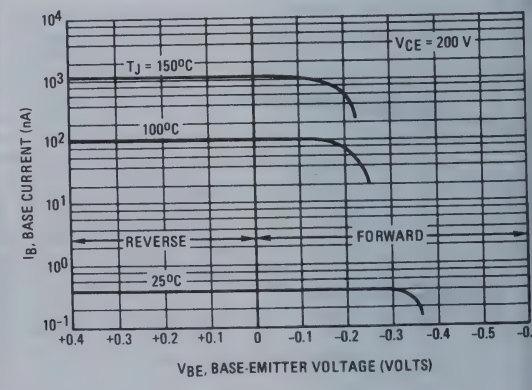


FIGURE 15 – BASE CUTOFF REGION





MJ3771, MJ3772, MJ6257 EPIBASE (SILICON)
2N3771, 2N3772, 2N6257 UNIBASE

HIGH POWER NPN SILICON POWER TRANSISTORS

Select from Epibase and/or Unibase (single diffused) transistors for ultimate circuit performance based on the design requirements.

EPIBASE – Designed for power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 15 Adc – MJ3771
  = 0.8 Vdc (Max) @ I_C = 10 Adc – MJ3772
  = 0.7 Vdc (Max) @ I_C = 8.0 Adc – MJ6257
- Low Leakage –
  I_{CBO} = 1.0 mAdc (Max) @ Rated V_{CB}
- High Current-Gain – Bandwidth Product –
  f_T = 2.0 MHz (Min) @ I_C = 1.0 Adc

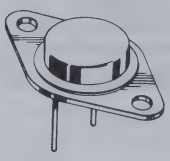
UNIBASE (Single Diffused) – Designed for series pass regulators and inductive switching applications.

- Forward Biased Second Breakdown Current Capability
  $I_{S/b}$ = 3.75 Adc @ V_{CE} = 40 Vdc – 2N3771
  = 2.5 Adc @ V_{CE} = 60 Vdc – 2N3772
  = 3.75 Adc @ V_{CE} = 40 Vdc – 2N6257
- Reverse Biased Second Breakdown Energy –
  $E_{S/b}$ = 500 mJ (Min) @ I_C = 5.0 Adc, L = 40 mH

20 and 30 AMPERE

POWER TRANSISTORS NPN SILICON

40 and 60 VOLTS
150 and 200 WATTS



*MAXIMUM RATINGS

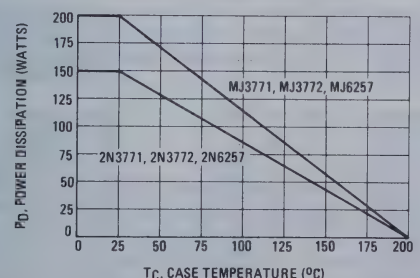
Rating	Symbol	2N3771 MJ3771	2N3772 MJ3772	2N6257 MJ6257	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	40	Vdc
Collector-Emitter Voltage	V_{CEX}	50	80	50	Vdc
Collector-Base Voltage	V_{CB}	50	100	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	5.0	Vdc
Collector Current – Continuous Peak	I_C	30 30	20 30		Adc
Base Current – Continuous Peak	I_B	7.5 15	5.0 15		Adc
		2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257		
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	200 1.14		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

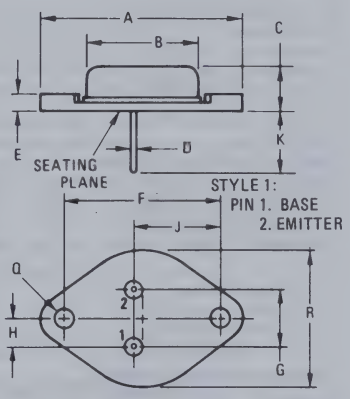
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	0.875	°C/W

*Indicates JEDEC Registered Data for 2N3771, 2N3772, 2N6257

FIGURE 1 – POWER DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.

CASE 11

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Unibase	Epibase	Symbol	Min	Max	Min	Max	Unit
OFF CHARACTERISTICS								
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	$V_{CEO(sus)}$	40 60 40	– – –	40 60 40	– – –	Vdc
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, $V_{EB(off)}$ = 1.5 Vdc, R_{BE} = 100 Ohms)	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	$V_{CEX(sus)}$	50 80 50	– – –	50 80 50	– – –	Vdc
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, R_{BE} = 100 Ohms)	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	$V_{CER(sus)}$	45 70 45	– – –	45 70 45	– – –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 50 Vdc, I_B = 0) (V_{CE} = 25 Vdc, I_B = 0)	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	I_{CEO}	– – –	10 10 10	– – –	2.0 2.0 2.0	mAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3771 2N3772 2N6257 2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257 MJ3771 MJ3772 MJ6257	I_{CEX}	– – – – – –	2.0 5.0 4.0 10 10 20	– – – – – –	1.0 1.0 1.0 2.0 2.0 5.0	mAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)* (V_{CB} = 100 Vdc, I_E = 0)	2N3771 2N6257 2N3772	MJ3771 MJ6257 MJ3772	I_{CBO}	– – –	2.0 4.0 5.0	– – –	1.0 1.0 1.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0) (V_{BE} = 7.0 Vdc, I_C = 0)	2N3771 2N6257 2N3772	MJ3771 MJ6257 MJ3772	I_{EBO}	– – –	5.0 10 5.0	– – –	1.0 1.0 1.0	mAdc
ON CHARACTERISTICS								
DC Current Gain (I_C = 15 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 30 Adc, V_{CE} = 4.0 Vdc) (I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N3771 2N3772 2N6257 2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257 MJ3771 MJ3772 MJ6257	h_{FE}	15 15 15 5.0 5.0 5.0	60 60 75 – – –	15 15 15 5.0 5.0 5.0	60 60 75 – – –	–
Collector-Emitter Saturation Voltage (I_C = 15 Adc, I_B = 1.5 Adc) (I_C = 10 Adc, I_B = 1.0 Adc) (I_C = 8.0 Adc, I_B = 0.8 Adc) (I_C = 30 Adc, I_B = 6.0 Adc) (I_C = 20 Adc, I_B = 4.0 Adc)	2N3771 2N3772 2N6257 2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257 MJ3771 MJ3772 MJ6257	$V_{CE(sat)}$	– – – – – –	2.0 1.4 1.5 4.0 4.0 4.0	– – – – – –	1.0 0.8 0.7 4.0 3.0 3.0	Vdc
Base-Emitter On Voltage (I_C = 15 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	2N3771 2N3772 2N6257	MJ3771 MJ3772 MJ6257	$V_{BE(on)}$	– – –	2.7 2.2 2.2	– – –	1.7 1.5 1.4	Vdc
DYNAMIC CHARACTERISTICS								
Current-Gain — Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 50 kHz) (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 1.0 MHz)	Unibase	Epibase	f_T	0.2	–	2.0	–	MHz MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	Unibase		h_{fe}	40	–	–	–	–
SWITCHING CHARACTERISTICS								
Rise Time Storage Time Fall Time	(V_{CC} = 30 Vdc, I_C = 10 Adc) I_{B1} = I_{B2} = 1.0 Adc)	Epibase	t_r t_s t_f	– – –	– – –	– – –	0.7 1.0 0.8	µs µs µs
Second Breakdown Energy with base forward biased, t = 1.0 s (non-repetitive) (V_{CE} = 40 Vdc) (V_{CE} = 60 Vdc)	2N3771 2N6257 2N3772		$I_{S/b}$	3.75 3.75 2.5	– – –	– – –	– – –	Adc
Second Breakdown Energy with base reverse biased (I_C = 5.0 Adc, V_{BE} = 1.5 Vdc, L = 50 mH, R_{BE} = 100 Ohms)	2N3771 2N3772 2N6257		$E_{S/b}$	500 500 500	– – –	– – –	– – –	mJ

*Indicates JEDEC Registered Data for 2N3771, 2N3772 and 2N6257.

FIGURE 2 – THERMAL RESPONSE – 2N3771, 2N3772, 2N6257

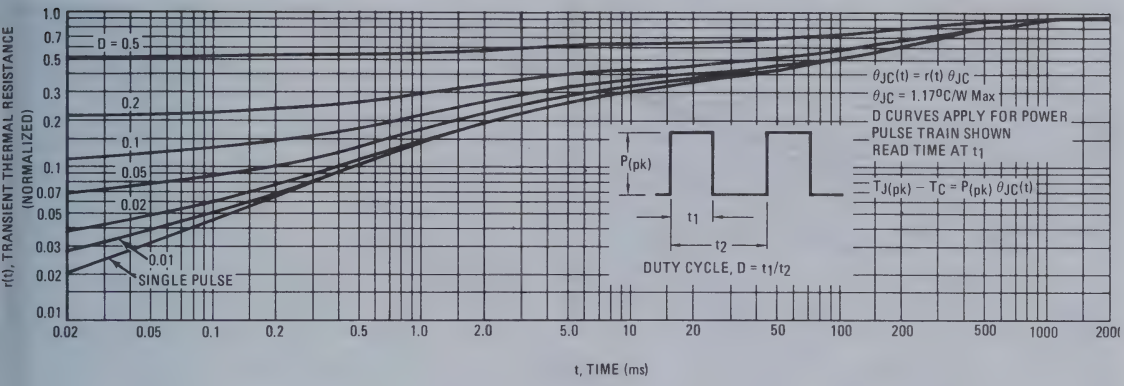
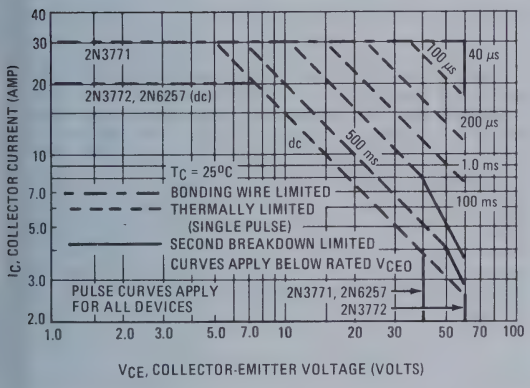


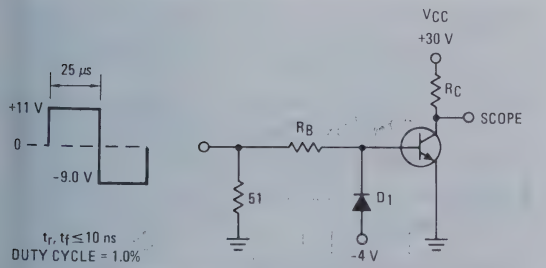
FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA – 2N3771, 2N3772, 2N6257



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Figure 3 is based upon JEDEC registered Data. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data of Figure 2. Using data of Figure 2 and the pulse power limits of Figure 3, $T_{J(pk)}$ will be found to be less than $T_{J(max)}$ for pulse widths of 1 ms and less. When using Motorola transistors, it is permissible to increase the pulse power limits until limited by $T_{J(max)}$.

FIGURE 4 – SWITCHING TIME TEST CIRCUIT



RB AND RC ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE IB ≈100 mA
MSD6100 USED BELOW IB ≈100 mA

FIGURE 5 – TURN-ON TIME

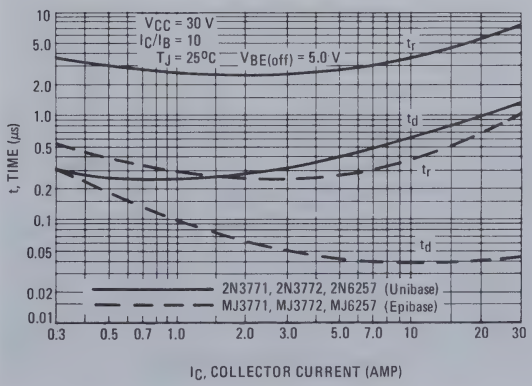


FIGURE 6 – THERMAL RESPONSE – MJ3771, MJ3772, MJ6257

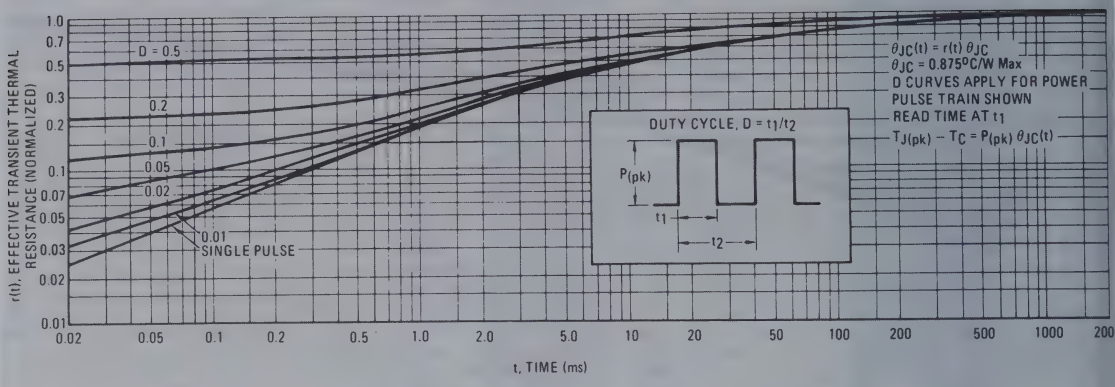
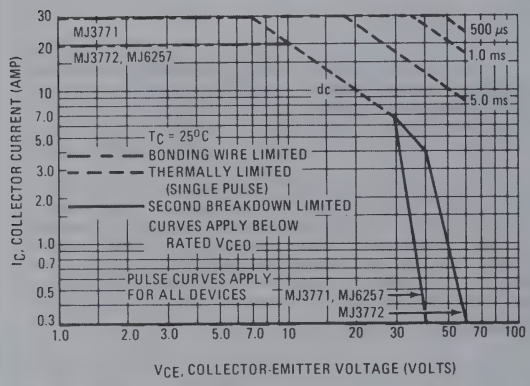


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA – MJ3771, MJ3772, MJ6257



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415)

FIGURE 8 – TURN-OFF TIME

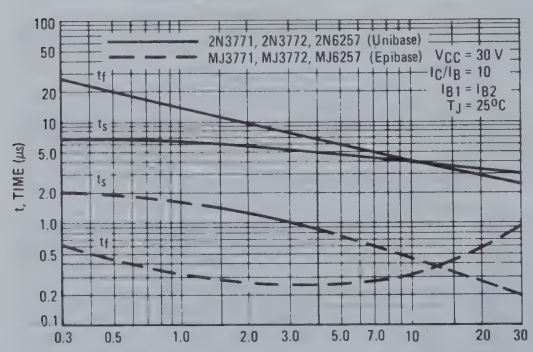
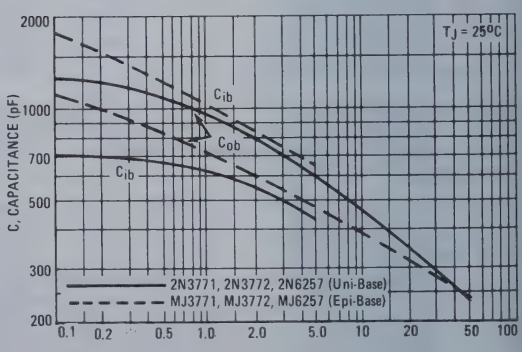


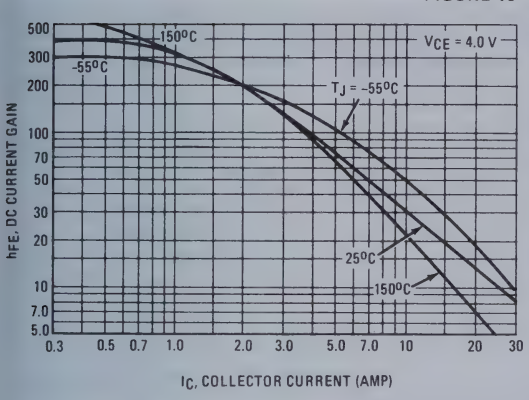
FIGURE 9 – CAPACITANCE



UNIBASE
2N3771, 2N3772, 2N6257

EPIBASE
MJ3771, MJ3772, MJ6257

FIGURE 10 – DC CURRENT GAIN



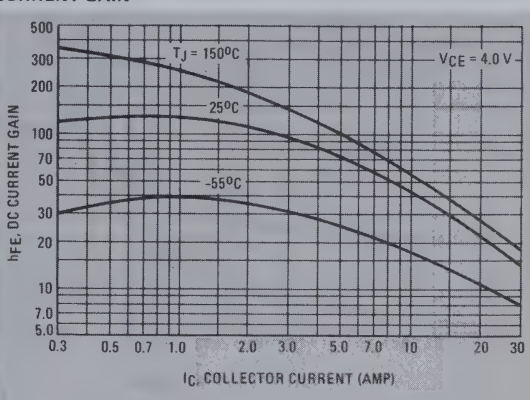
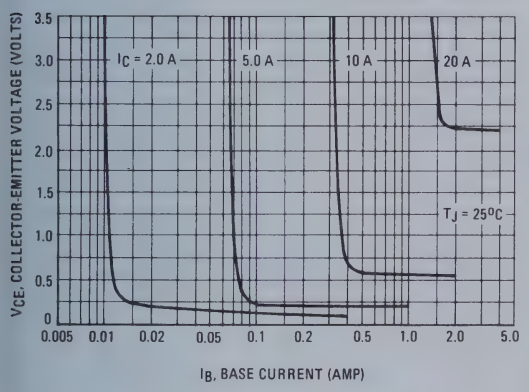


FIGURE 11 – COLLECTOR SATURATION REGION



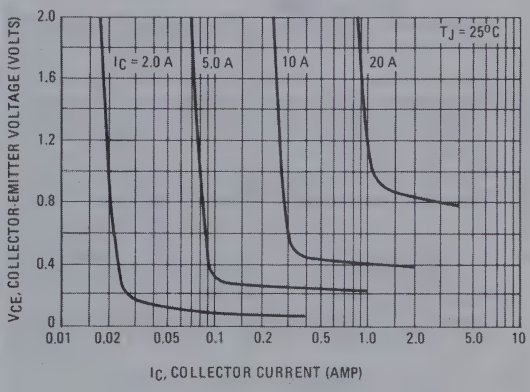
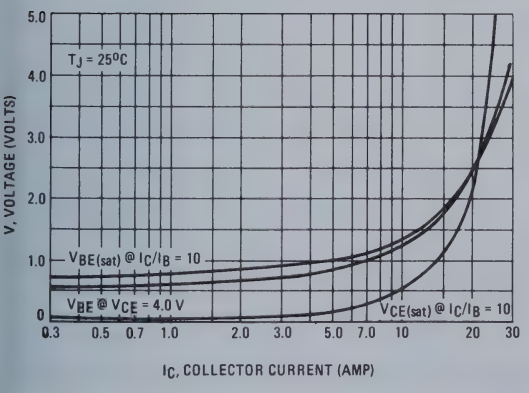
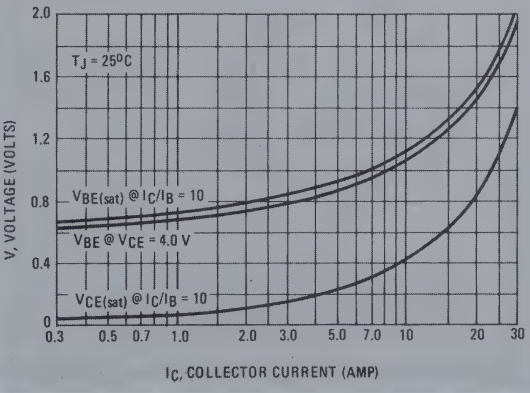


FIGURE 12 – "ON" VOLTAGES

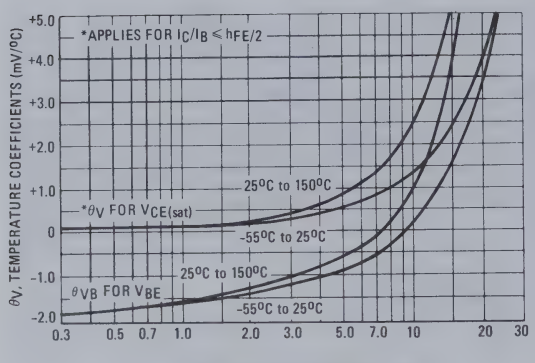




UNIBASE
2N3771, 2N3772, 2N6257

EPIBASE
MJ3771, MJ3772, MJ6257

FIGURE 13 – TEMPERATURE COEFFICIENTS



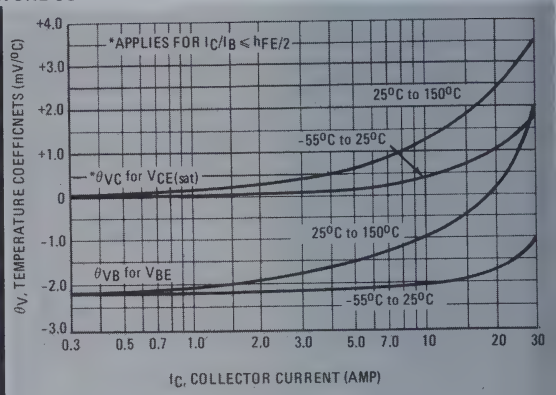
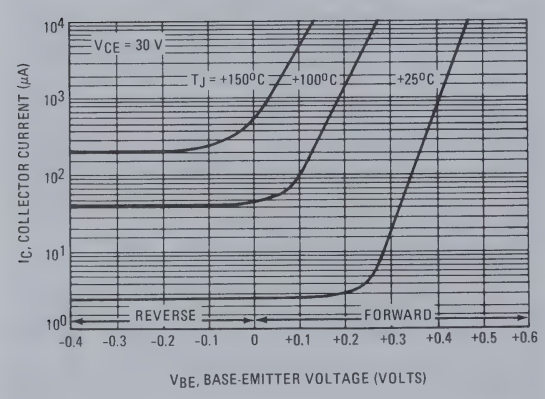
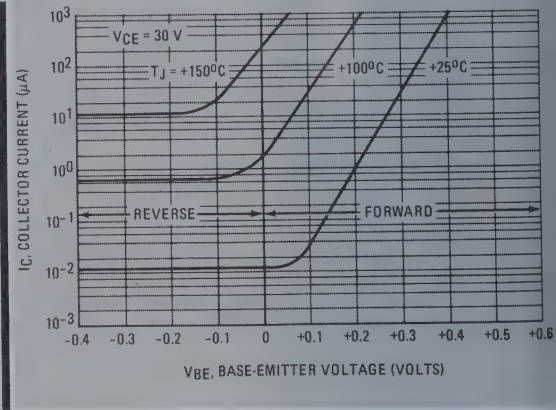


FIGURE 14 – COLLECTOR CUTOFF REGION





MJ4000, MJ4001 NPN (SILICON)
MJ4010, MJ4011 PNP

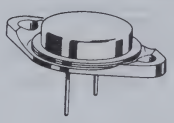
MEDIUM-POWER COMPLEMENTARY
SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 2500 (Typ) @ I_C = 1.5 Adc
- Monolithic Construction

4.0 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

60–80 VOLTS
75 WATTS



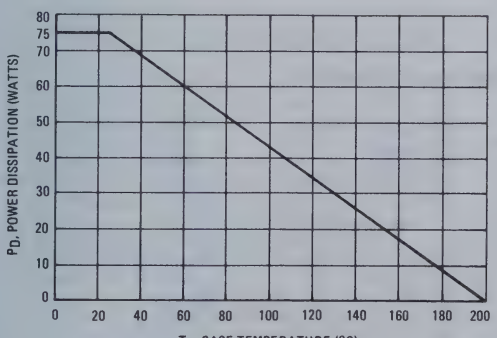
MAXIMUM RATINGS

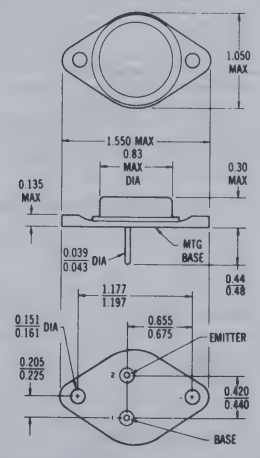
Rating	Symbol	MJ4000 MJ4010	MJ4001 MJ4011	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	4.0		Adc
Base Current	I_B	0.05		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	75 0.428		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.33	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





TO-3
CASE 11
Collector connected to case

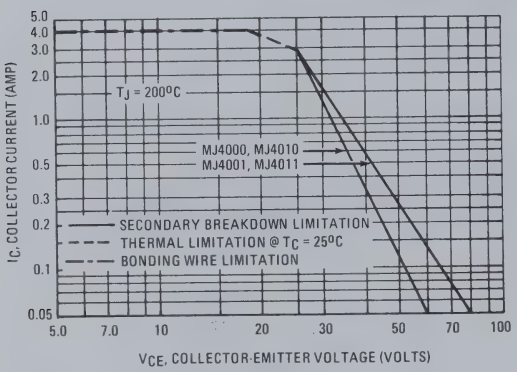
All JEDEC TO-3 dimensions and notes apply.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 50 mAdc, I_B = 0)	MJ4000, MJ4010	BV_{CEO}	60	–	Vdc
	MJ4001, MJ4011		80	–	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJ4000, MJ4010		–	0.20	
(V_{CB} = 80 Vdc, I_E = 0)	MJ4001, MJ4011		–	0.20	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ4000, MJ4010		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ4001, MJ4011			2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ4000, MJ4010		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJ4001, MJ4011		–	500	
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 1.5 Adc, I_B = 6.0 mAdc)		$V_{CE(sat)}$	–	2.0	Vdc
Base-Emitter Voltage(1) (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	2.5	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

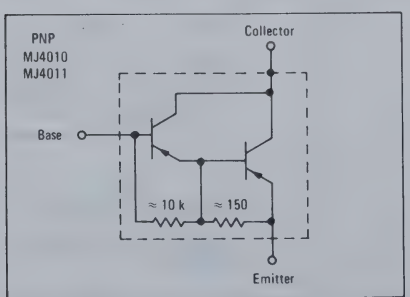
FIGURE 2 – DC SAFE OPERATING AREA

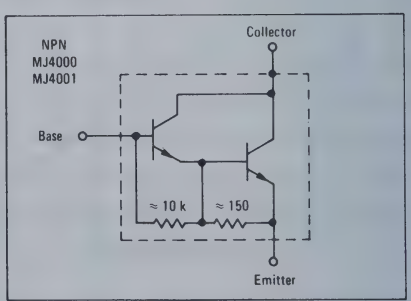


There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC





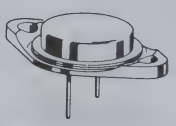
MJ4030, MJ4031, MJ4032 PNP (SILICON)
MJ4033, MJ4034, MJ4035 NPN

MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain — h_{FE} = 3500 (Typ) @ I_C = 10 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor

16 AMPERE
DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON
60–100 VOLTS
150 WATTS



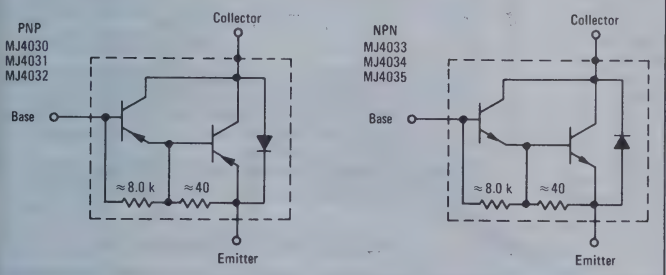
MAXIMUM RATINGS

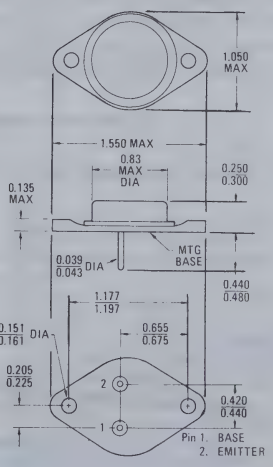
Rating	Symbol	MJ4030 MJ4033	MJ4031 MJ4034	MJ4032 MJ4035	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current	I_C	16			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	150 0.857			Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	$^oC/W$

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC





All JEDEC dimensions and notes apply

Collector connected to case

CASE 11
TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, I_B = 0)	MJ4030, MJ4033	BV_{CEO}	60	–	Vdc
	MJ4031, MJ4034		80	–	
	MJ4032, MJ4035		100	–	
Collector Emitter Leakage Current		I_{CER}			mAdc
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm)	MJ4030, MJ4033		–	1.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm)	MJ4031, MJ4034		–	1.0	
(V_{CB} = 100 Vdc, R_{BE} = 1.0 k ohm)	MJ4032, MJ4035		–	1.0	
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ4030, MJ4033		–	5.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ4031, MJ4034		–	5.0	
(V_{CB} = 100 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ4032, MJ4035		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ4030, MJ4033		–	3.0	
(V_{CE} = 40 Vdc, I_B = 0)	MJ4031, MJ4034		–	3.0	
(V_{CE} = 50 Vdc, I_B = 0)	MJ4032, MJ4035		–	3.0	
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 40 mAdc)			–	2.5	
(I_C = 16 Adc, I_B = 80 mAdc)			–	4.0	
Base-Emitter Voltage (I_C = 10 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	3.0	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

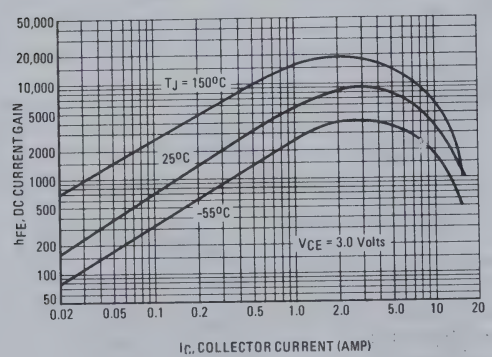


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

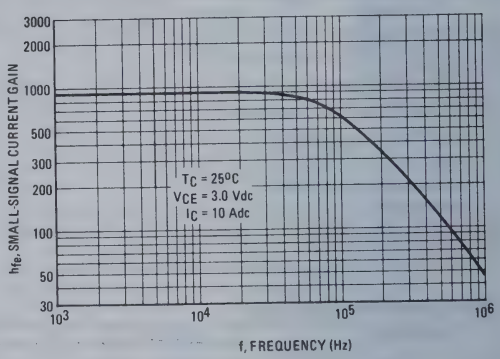


FIGURE 4 – "ON" VOLTAGES

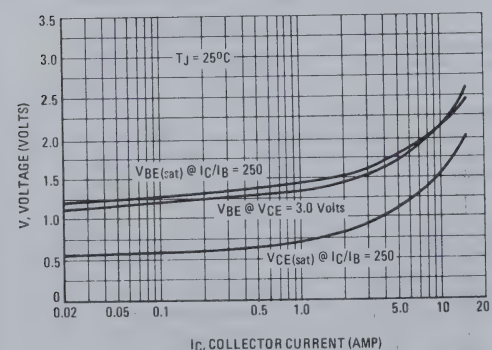
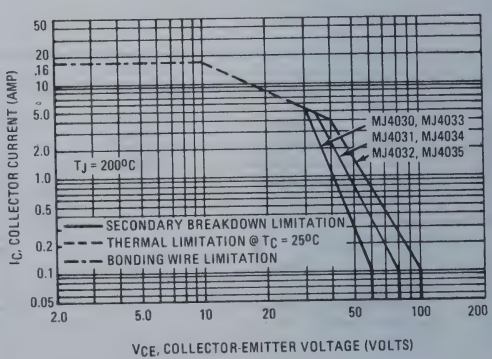


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ4200, MJ4201 NPN (SILICON)
MJ4210, MJ4211 PNP

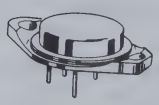
DUAL SILICON POWER DARLINGTON TRANSISTORS

. . . designed for hammer driver, regulator and amplifier applications.

- High DC Current Gain –
  h_{FE} = 3000 (Typ) @ I_C = 2.0 Adc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 60 Vdc – MJ4200, MJ4210
  = 80 Vdc – MJ4201, MJ4211
- Total Monolithic Construction
  Dual transistors in the same chip, yielding like electrical characteristics. Collectors are common

DUAL DARLINGTON
4 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS

60, 80 VOLTS
85 WATTS

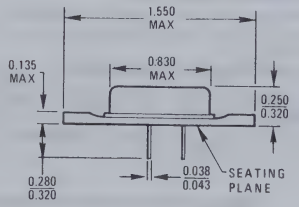


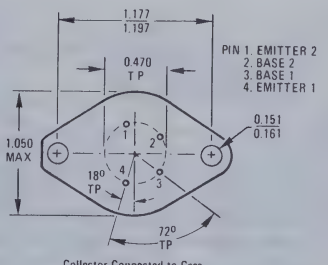
MAXIMUM RATINGS

Rating	Symbol	MJ4200 MJ4210	MJ4201 MJ4211	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous – Peak	I_C	4.0 8.0		Adc
Base Current	I_B	80		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Equal power in both transistors)	P_{DT}	85 0.485		Watts W/°C
Single Transistor Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 0.343		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65°C to +200°C		°C

THERMAL CHARACTERISTICS

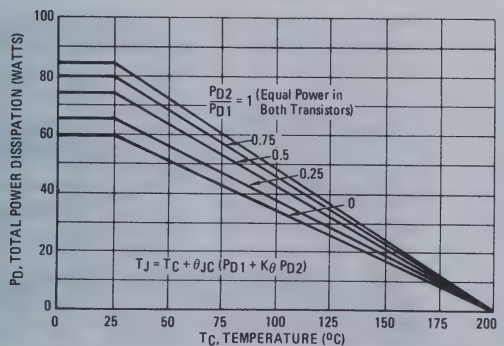
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case Single Transistor Effective, equal power both transistors	θ_{JC}	 2.92 2.06	°C/W
Thermal Coupling Factor	K_θ	41	%





Collector Connected to Case.
CASE 253

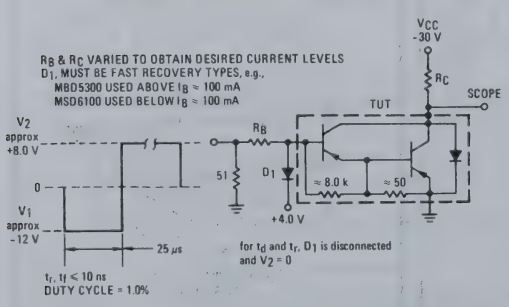
FIGURE 1 – POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	MJ4200, MJ4210 MJ4201, MJ4211	$V_{CEO(sus)}$	 60 80	 – –	Vdc
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ4200, MJ4210		–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	MJ4201, MJ4211		–	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)	MJ4200, MJ4201		–	0.5	
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)	MJ4210, MJ4211		–	0.5	
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ4200, MJ4201		–	5.0	
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ4210, MJ4211		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)			750	18000	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)			100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 8.0 mAdc)			–	2.0	
(I_C = 4.0 Adc, I_B = 40 mAdc)			–	3.0	
Base-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 40 mAdc)		$V_{BE(sat)}$	–	4.0	Vdc
Base-Emitter On Voltage (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common-Emitter Small-Signal Short-Circuit Forward Current Transfer Ratio (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	4.0	–	–
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJ4200, MJ4201		–	120	
	MJ4210, MJ4211		–	200	
Small-Signal Current Gain (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



For NPN test circuit reverse all polarities.

FIGURE 3 – SWITCHING TIMES

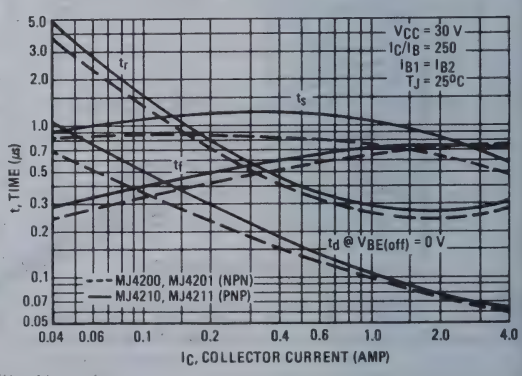


FIGURE 4 – THERMAL RESPONSE

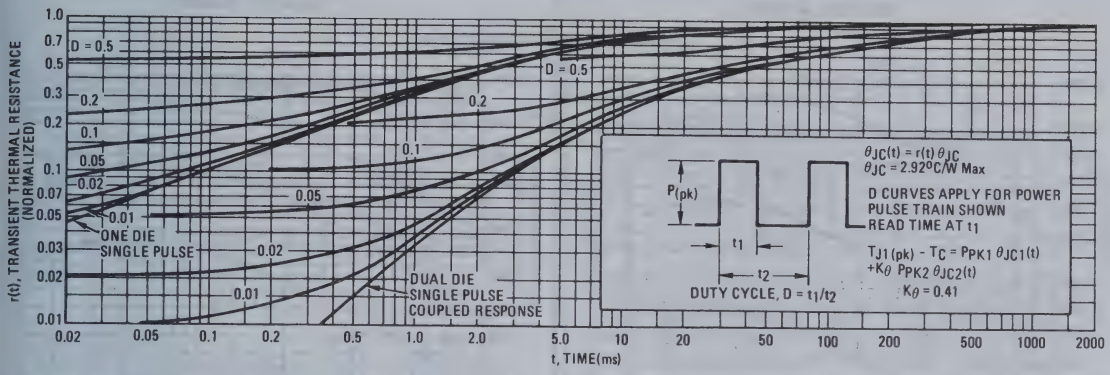
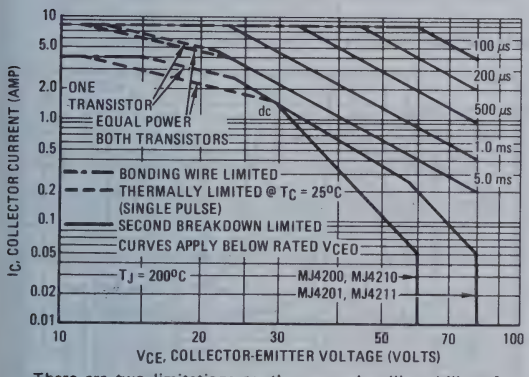


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor – average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

NOTE

Computing Peak Junction Temperature

Use $T_{J1(pk)} - T_C = P_{PK1}\,\theta_{JC1(t)} + K_\theta\,P_{PK2}\,\theta_{JC2(t)}$

Example: $P_{PK1} = 80$ W, $P_{PK2} = 50$ W } Pulse Coincident at Trailing Edge

$t_1 = 5$ ms, $t_1 = 10$ ms } Pulse Coincident at Trailing Edge

$D = 20\%$, $D = 20\%$ } Pulse Coincident at Trailing Edge

Read $r(t) = 0.58$, $r(t) = 0.35$ (from Figure 4)

$\therefore \theta_{JC1(t)} = 1.69^oC/W$ $\therefore \theta_{JC2(t)} = 1.02^oC/W$

$T_{J1(pk)} - T_C = (80)(1.69) + (0.41)(50)(1.02)$

$= 135 + 21 = 156^oC$

Where the side having highest junction temperature is not obvious, both sides should be checked.

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

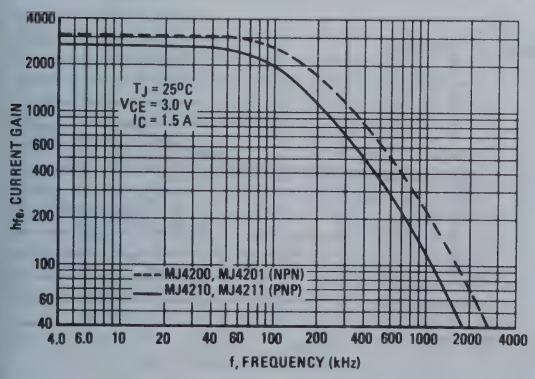
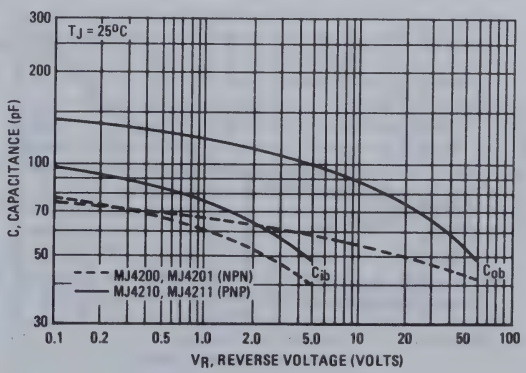


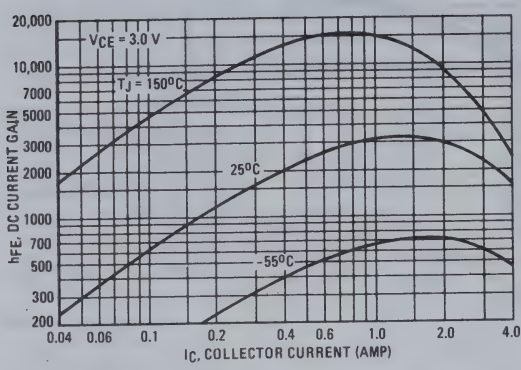
FIGURE 7 – CAPACITANCE



NPN
MJ4200, MJ4201

PNP
MJ4210, MJ4211

FIGURE 8 – DC CURRENT GAIN



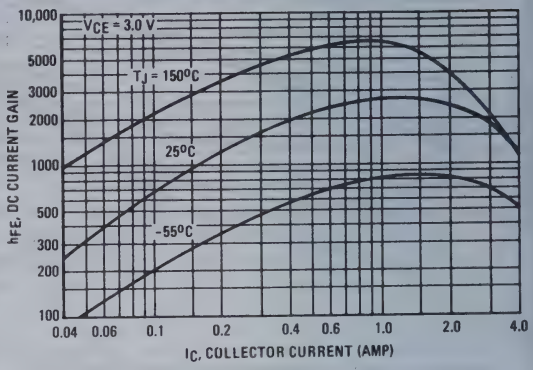
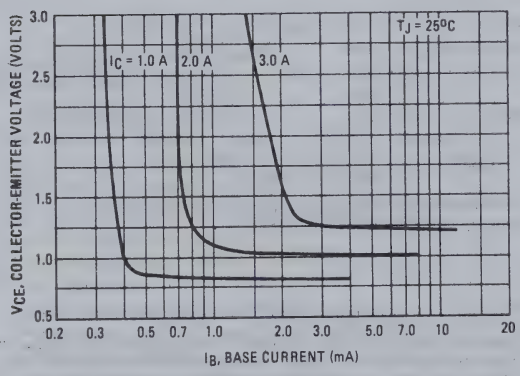


FIGURE 9 – COLLECTOR SATURATION REGION



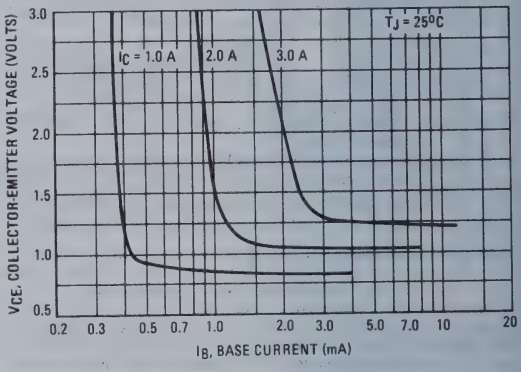
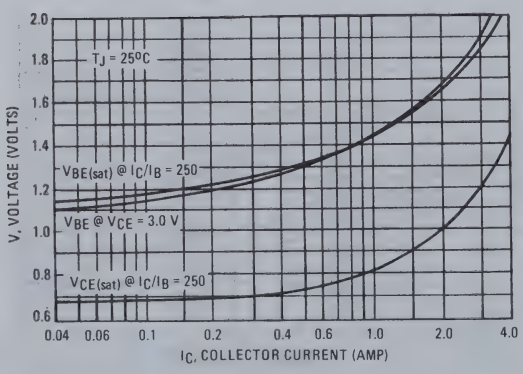
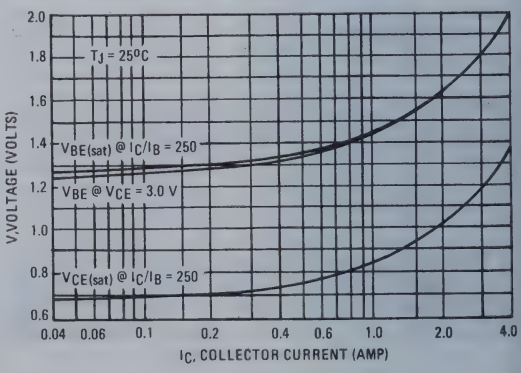


FIGURE 10 – ON VOLTAGES





NPN
MJ4200, MJ4201

PNP
MJ4210, MJ4211

FIGURE 11 – TEMPERATURE COEFFICIENTS

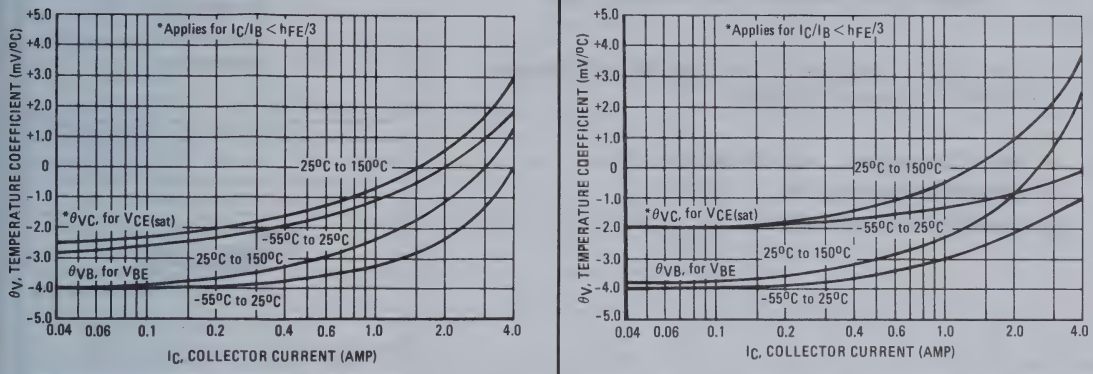


FIGURE 12 – COLLECTOR CUTOFF REGION

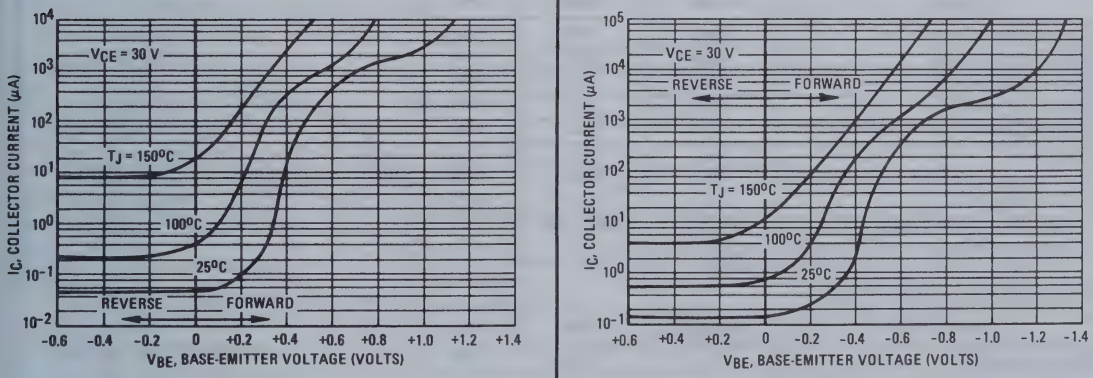
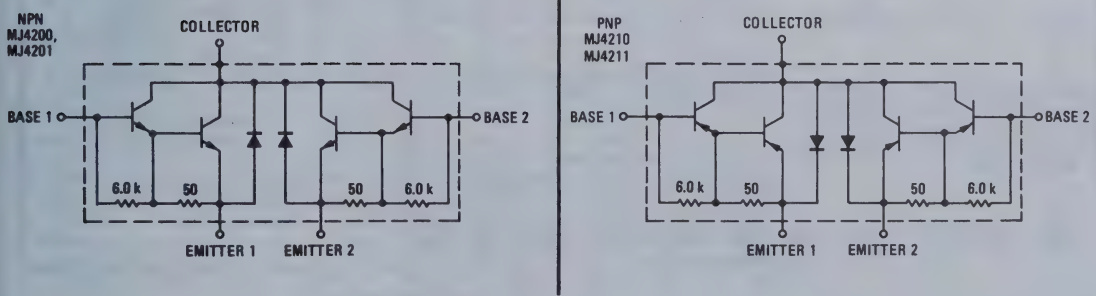


FIGURE 13 – DARLINGTON SCHEMATIC



MJ4502 (SILICON)

HIGH-POWER PNP SILICON TRANSISTOR

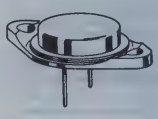
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25–100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the NPN MJ802

30 AMPERE
POWER TRANSISTOR

PNP SILICON

100 VOLTS
200 WATTS



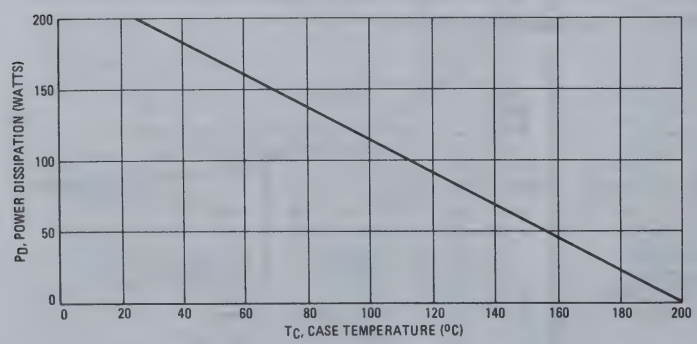
MAXIMUM RATINGS

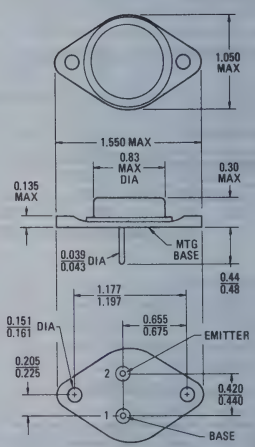
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 11
(TO-3)

Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	V_{CER}	100	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc)	$BV_{CEO(sus)}$	90	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)		–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter "On" Voltage* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.3	Vdc
Collector-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

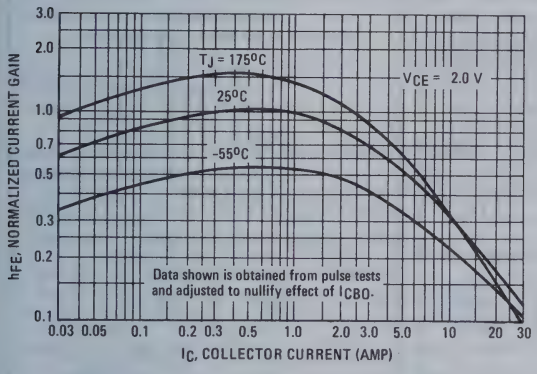


FIGURE 3 – "ON" VOLTAGES

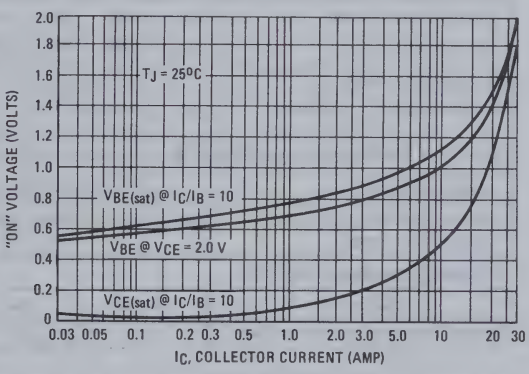
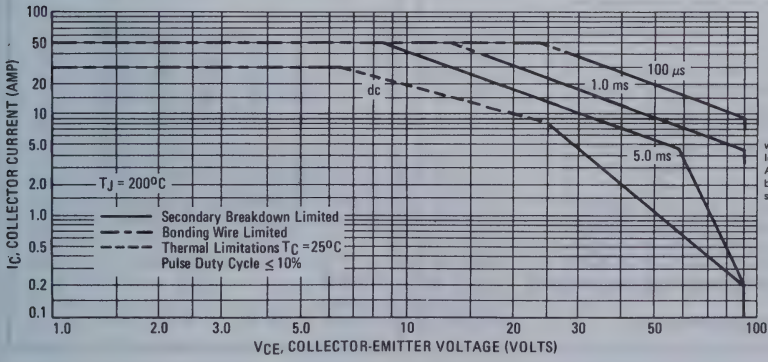


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ4645 thru MJ4648 (SILICON)

PNP SILICON POWER TRANSISTORS

. . . designed for high-voltage amplifier and saturated switching applications at collector currents to one Ampere. Ideally suited for applications of dc-to-dc converters, relay and hammer drivers, motor controls, and servo and pulse amplifiers. High-voltage ratings permit direct-line operation.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = < 1.5 Vdc (Max) @ I_C = 500 mAdc
- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 200, 300, 350 and 400 Vdc (Min)
- DC Current Gain Specified – 10 mAdc to 500 mAdc

1.0 AMPERE
POWER TRANSISTORS
PNP SILICON
200-300-350-400 VOLTS
5 WATTS



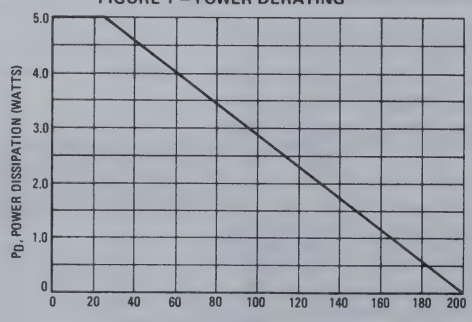
MAXIMUM RATINGS

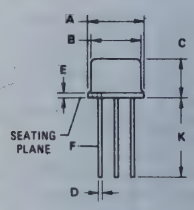
Rating	Symbol	MJ4645	MJ4646	MJ4647	MJ4648	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	400	350	Vdc
Collector-Base Voltage	V_{CB}	200	300	400	350	Vdc
Emitter-Base Voltage	V_{EB}	5.0				Vdc
Collector Current – Continuous Peak	I_C	0.5 1.0				Adc
Total Device Dissipation @ T_C = 25°C	P_D	5.0				Watts
Derate above 25°C		28.6				mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200				°C

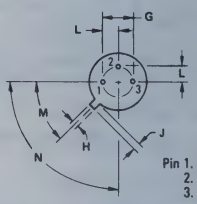
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W

FIGURE 1 – POWER DERATING







Pin 1. Emitter
2. Base
3. Collector

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.016	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	– –	12.700	– –
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

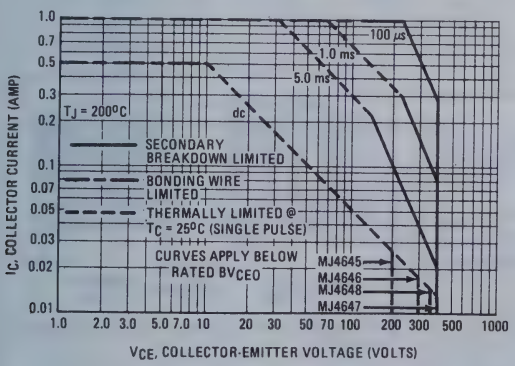
Collector connected to case.
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}				Vdc
	MJ4645		200	–	–	
	MJ4646		300	–	–	
	MJ4647		400	–	–	
	MJ4648		350	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}				Vdc
	MJ4645		200	–	–	
	MJ4646		300	–	–	
	MJ4647		400	–	–	
	MJ4648		350	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{CEX}	–	–	10	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			20	–	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc) (1)			25	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (1)			20	–	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$				Vdc
	MJ4645		–	0.5	1.0	
	MJ4646		–	0.6	1.2	
	MJ4647, MJ4648		–	0.75	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T				MHz
	MJ4645, MJ4646		40	–	–	
	MJ4647, MJ4648		30	–	–	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}				pF
	MJ4645		–	–	80	
	MJ4646, MJ4647, MJ4648		–	–	60	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_d	–	–	100	ns
Rise Time	I_{B1} = 50 mAdc, $V_{BE(off)}$ = 5.0 Vdc)	t_r	–	–	100	ns
Turn-Off Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, Pulse Width = 1.0 μs)	t_{off}	–	–	720	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJ5415, MJ5416 PNP (SILICON)
2N3439, 2N3440 NPN

COMPLEMENTARY SILICON HIGH VOLTAGE POWER TRANSISTORS

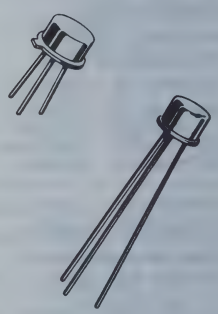
. . . designed for use in consumer and industrial line-operated applications. These devices are particularly suited for audio, video and differential amplifiers as well as high-voltage, low-current inverters, switching and series pass regulators.

- High DC Current Gain –
  h_{FE} = 40-160 @ I_C = 20 mAdc – 2N3439, 2N3440
  = 30-150 @ I_C = 50 mAdc – MJ5415
  = 30-120 @ I_C = 50 mAdc – MJ5416
- Current-Gain – Bandwidth Product –
  f_T = 15 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance @ f = 1.0 MHz –
  C_{ob} = 10 pF (Max) – 2N3439, 2N3440
  = 25 pF (Max) – MJ5415, MJ5416

1 AMPERE POWER TRANSISTORS

COMPLEMENTARY SILICON

200-350 VOLTS
5 and 10 WATTS



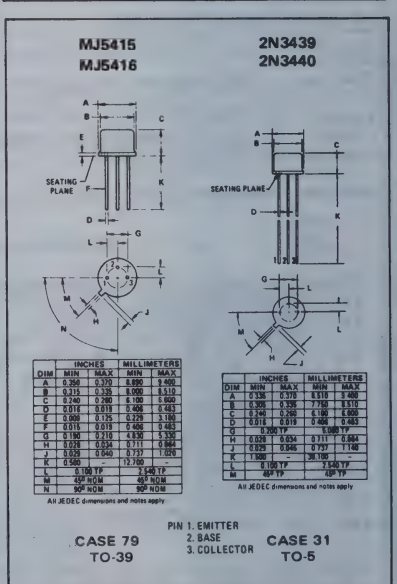
***MAXIMUM RATINGS**

Rating	Symbol	PNP MJ5415	PNP MJ5416	NPN 2N3439	NPN 2N3440	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V_{CB}	200	350	450	300	Vdc
Emitter-Base Voltage	V_{EB}	4.0	7.0	7.0	7.0	Vdc
Collector Current – Continuous	I_C	← 1.0 →				Adc
Base Current	I_B	← 0.5 →				Adc
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	1.0 6.7		– –		Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	– –		1.0 5.7		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57		5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← –65 to +200 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJ5415,MJ5416	2N3439,2N3440	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	150	175	°C/W

*Indicates JEDEC Registered Data.



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.336	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.090	0.125	0.229	3.180
F	0.015	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.029	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.335	0.370	8.510	9.400
B	0.305	0.335	7.750	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
G	0.200 TP		5.080 TP	
H	0.029	0.034	0.711	0.864
J	0.029	0.045	0.737	1.143
K	1.500	–	38.100	–
L	0.100 TP		2.540 TP	
M	45° TP		45° TP	

All JEDEC dimensions and notes apply.

CASE 79
TO-39

PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
TO-5

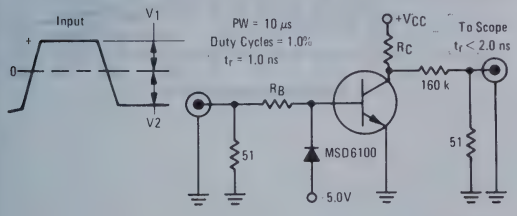
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 10 mAdc, I_B = 0)	MJ5415		200	–	
	MJ5416		300	–	
(I_C = 50 mAdc, I_B = 0)	2N3439		350	–	
	2N3440		250	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	2N3439		–	20	
(V_{CE} = 200 Vdc, I_B = 0)	2N3440		–	50	
(V_{CE} = 150 Vdc, I_B = 0)	MJ5415,MJ5416		–	50	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3439		–	500	
(V_{CE} = 300 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3440		–	500	
*Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 175 Vdc, I_E = 0)	MJ5415		–	50	
(V_{CB} = 280 Vdc, I_E = 0)	MJ5416		–	50	
(V_{CB} = 360 Vdc, I_E = 0)	2N3439		–	20	
(V_{CB} = 250 Vdc, I_E = 0)	2N3440		–	20	
*Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 4.0 Vdc, I_C = 0)	MJ5415		–	20	
(V_{EB} = 6.0 Vdc, I_C = 0)	MJ5416,2N3439,2N3440		–	20	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	2N3439		30	–	
*(I_C = 20 mAdc, V_{CE} = 10 Vdc)	2N3439,2N3440		40	160	
*(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJ5415		30	150	
	MJ5416		30	120	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
*(I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439,2N3440		–	0.5	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MJ5415,MJ5416		–	2.5	
*Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439,2N3440		–	1.3	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJ5415,MJ5416		–	1.5	
DYNAMIC CHARACTERISTICS					
*Current-Gain – Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)			15	–	
*Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MJ5415,MJ5416		–	25	
	2N3439,2N3440		–	10	
*Input Capacitance		C_{ib}			pF
(V_{EB} = 5.0 Vdc, I_C = 0, f = 1.0 MHz)			–	75	
*Small-Signal Current Gain		h_{fe}			–
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	–	
*Real Part of Common Emitter Small-Signal Short-Circuit Input Impedance		$Re(h_{ie})$			Ohms
(V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 MHz)			–	300	

*Indicates JECEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(off)}$ = 150 V and I_C as desired, R_B chosen for desired I_{B1}, $V_1 \approx 10$ V, $V_2 \approx 8.0$ V

For t_d and t_r, D1 is disconnected and V_2 = 2.0 V

For PNP test circuit, reverse all polarities.

PNP
MJ5415, MJ5416

NPN
2N3449, 2N3440

FIGURE 2 – TURN-ON TIME

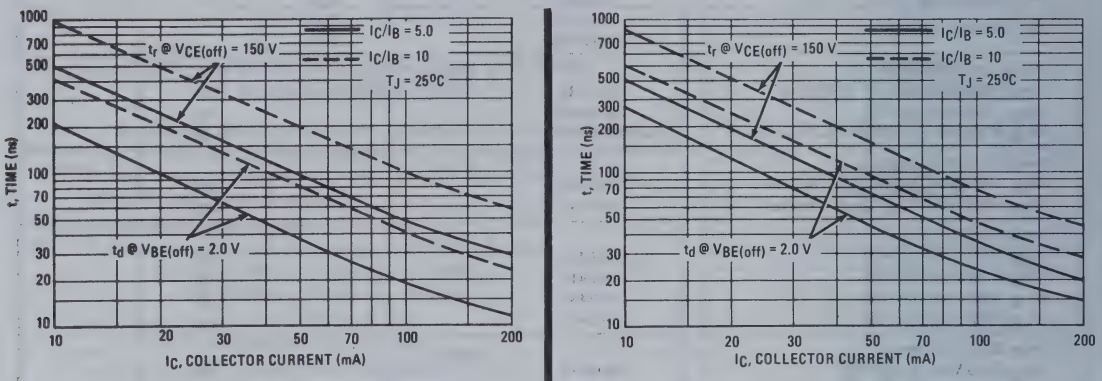


FIGURE 3 – TURN-OFF TIME

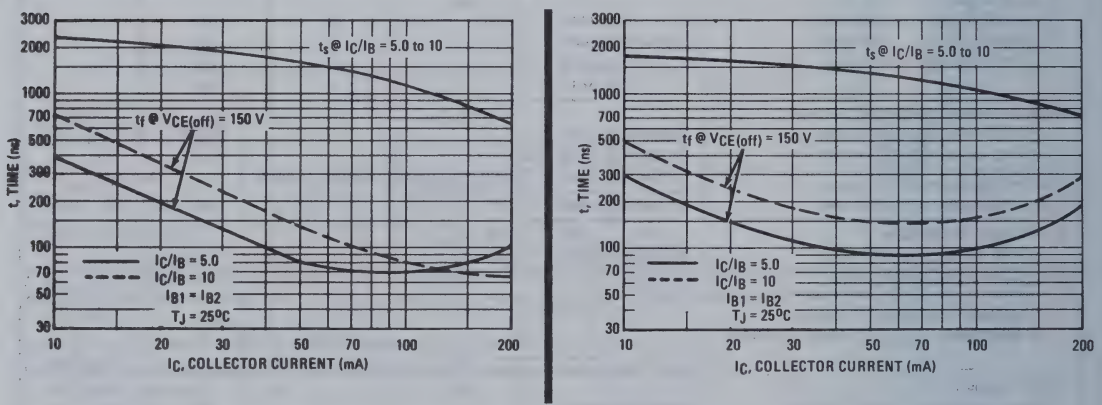


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

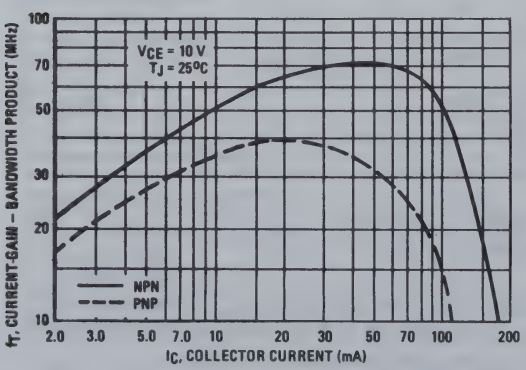


FIGURE 5 – CAPACITANCE

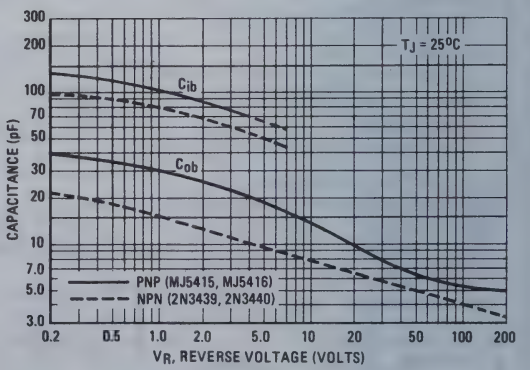


FIGURE 6 – THERMAL RESPONSE

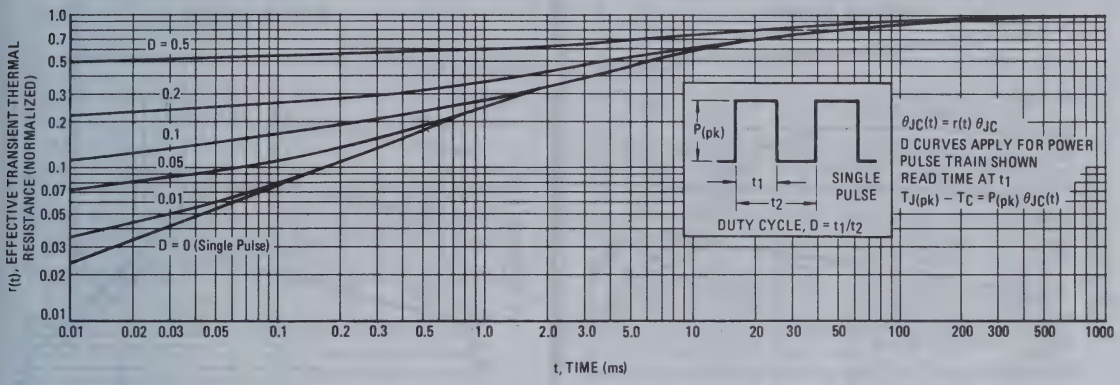
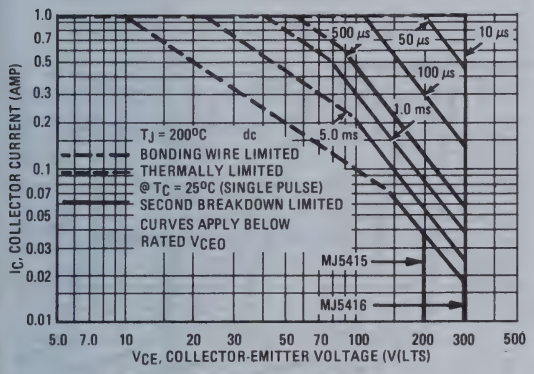


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

PNP – MJ5415, MJ5416



NPN – 2N3439, 2N3440

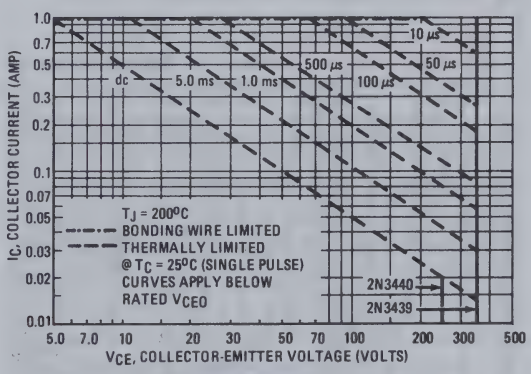
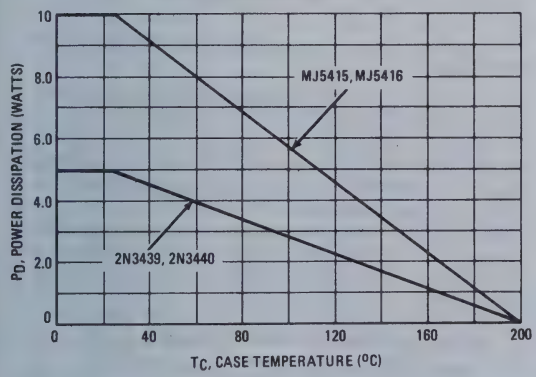


FIGURE 8 – POWER DERATING



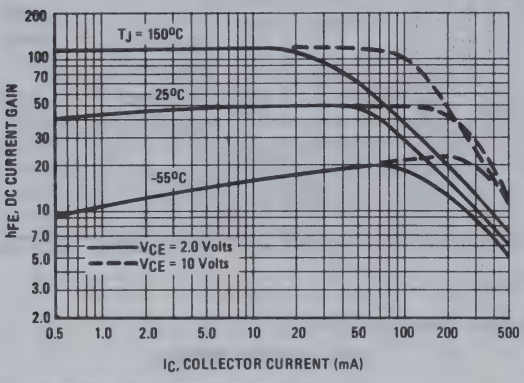
There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

PNP
MJ5415, MJ5416

NPN
2N3439 2N3440

FIGURE 9 – DC CURRENT GAIN



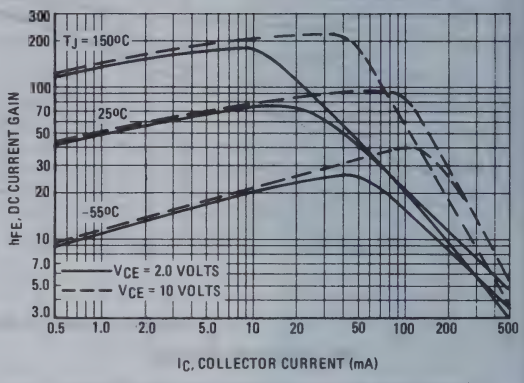
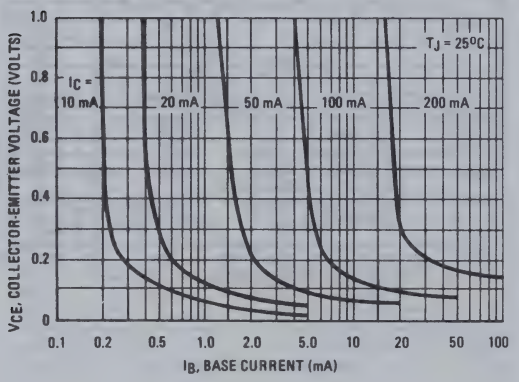


FIGURE 10 – COLLECTOR SATURATION REGION



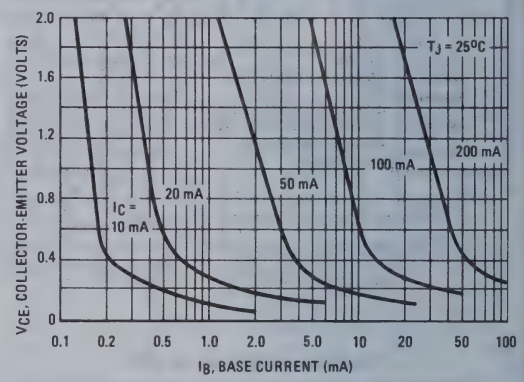
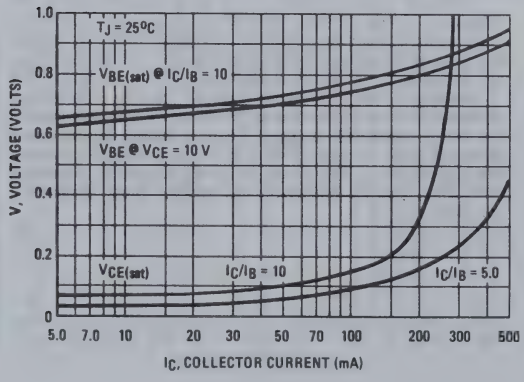


FIGURE 11 – "ON" VOLTAGES



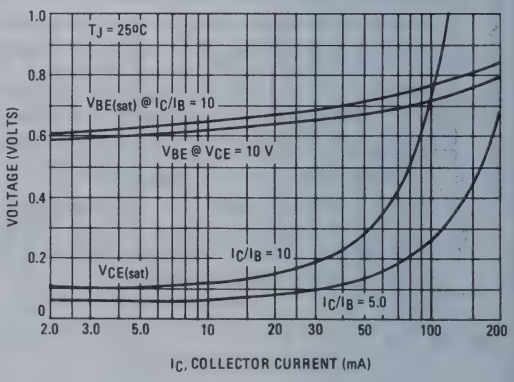


FIGURE 12 – TEMPERATURE COEFFICIENTS

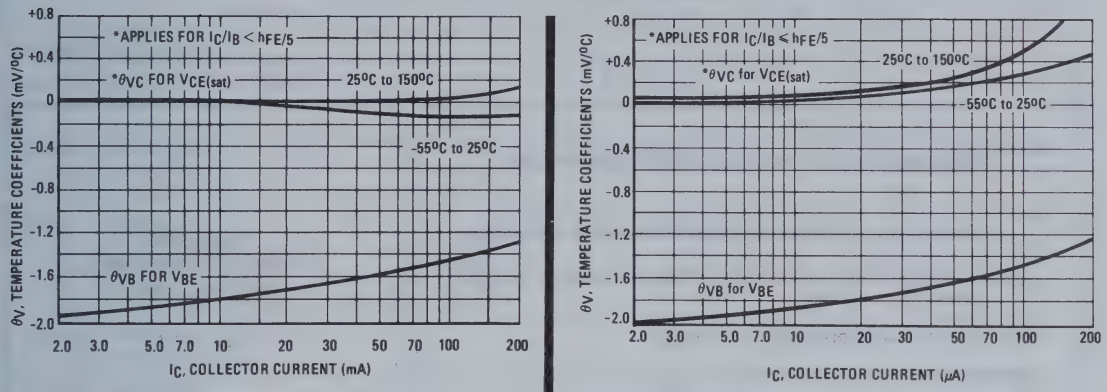


FIGURE 13 – COLLECTOR CUTOFF REGION

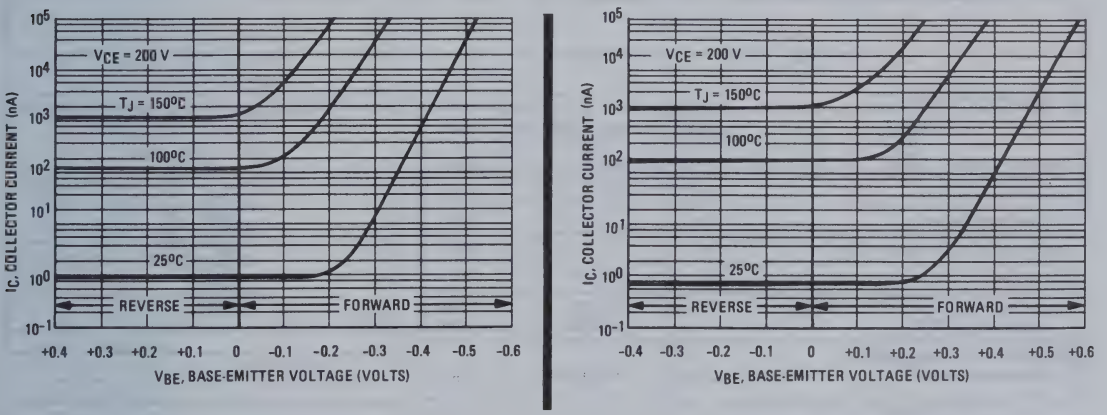
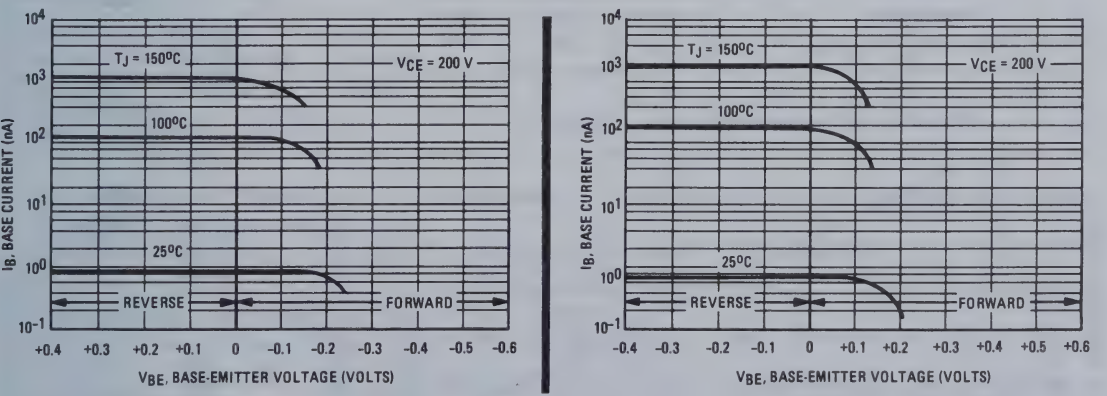


FIGURE 14 – BASE CUTOFF REGION



MJ6257 (SILICON)

For Specifications See MJ3771 Data, Volume I.

MJ6700 (SILICON)
MJ6701

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

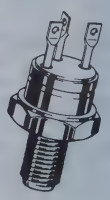
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration — 700 V Breakdown

7 AMPERE
POWER TRANSISTORS
PNP SILICON

60-80 VOLTS
60 WATTS

MAXIMUM RATINGS

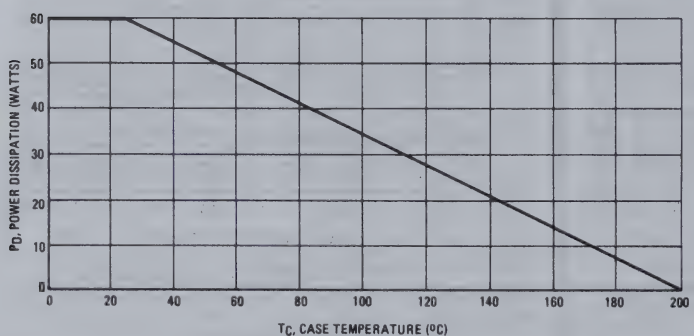
Rating	Symbol	MJ6700	MJ6701	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 343		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C



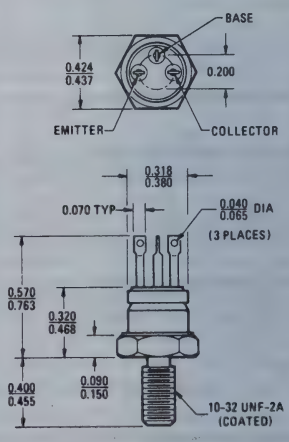
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



Isolated Collector

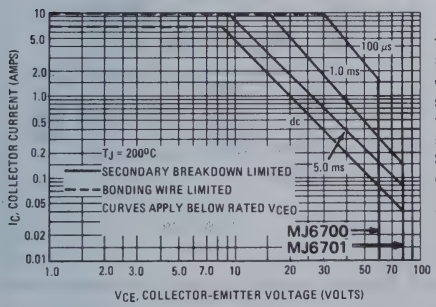
CASE 160
TO-59

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage [1] (I_C = 50 mAdc, I_B = 0)	MJ6700	$V_{CEO(sus)}$	60	–	Vdc
	MJ6701		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 55 Vdc, I_B = 0)	MJ6700		–	100	
(V_{CE} = 75 Vdc, I_B = 0)	MJ6701		–	100	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ6700		–	10	μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ6701		–	10	
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6700		–	1.0	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6701		–	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS [1]					
DC Current Gain		h_{FE}			–
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)			25	–	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			25	180	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	0.7	
(I_C = 7.0 Adc, I_B = 0.7 Adc)			–	1.2	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	1.2	
(I_C = 7.0 Adc, I_B = 0.7 Adc)			–	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)	t_f	–	150	ns

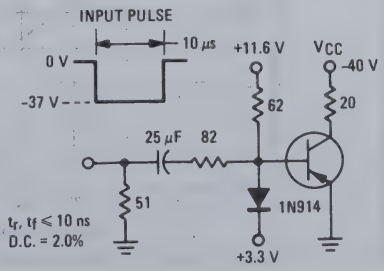
[1] Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ7000 (SILICON)

HIGH-POWER NPN SILICON TRANSISTOR

. . . designed for use in industrial power amplifier and switching circuits applications.

- High DC Current Gain –
  h_{FE} = 20–100 @ I_C = 10 Adc
- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) @ I_C = 100 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.7 Vdc (Max) @ I_C = 30 Adc

30 AMPERE
POWER TRANSISTOR
NPN SILICON

100 VOLTS
150 WATTS



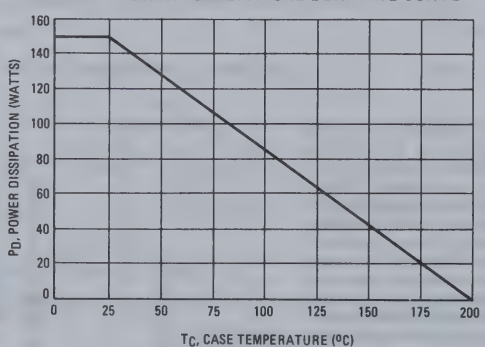
MAXIMUM RATINGS

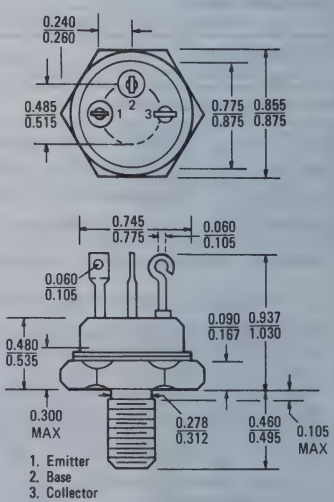
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	30	Adc
Base Current – Continuous	I_B	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.855	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 188
TO-63

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage [1] (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	100	–	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, I_B = 0)	I_{CEO}	–	10	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	5.0	μAdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	5.0	μAdc
Emitter-Base Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	μAdc
ON CHARACTERISTICS [1]				
DC Current Gain	h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		20	–	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		20	100	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.0	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	1.7	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.7	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	2.25	
Base-Emitter On Voltage (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	600	pF

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MJ7200 (SILICON)
MJ7201

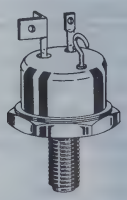
HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in high reliability power amplifier and switching circuits applications.

- High DC Current Gain –
  h_{FE} = 20–100 @ I_C = 20 Adc
- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) @ I_C = 200 mAdc – MJ7201
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc (Max) @ I_C = 40 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 20 MHz (Min) @ I_C = 0.7 Adc

60 AMPERE
POWER TRANSISTORS
NPN SILICON

80–100 VOLTS
300 WATTS



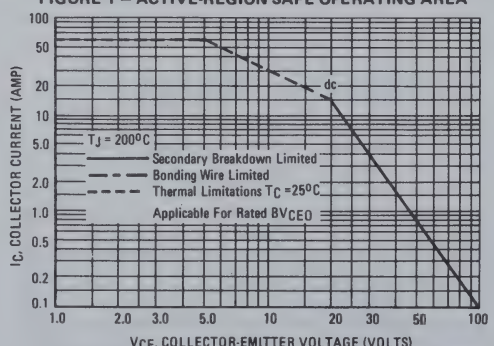
MAXIMUM RATINGS

Rating	Symbol	MJ7200	MJ7201	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous Peak	I_C	60 90		Adc
Base Current – Continuous	I_B	20		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

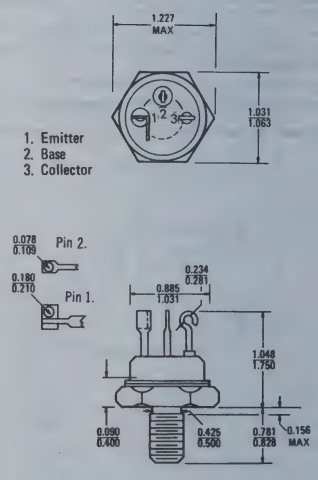
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.58	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 177
TO-114

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	MJ7200	$V_{CEO(sus)}$	80	–	Vdc
	MJ7201		100	–	
Collector-Emitter Cutoff Current		I_{CEX}			
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ7200		–	100	μAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ7201		–	100	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ7200		–	2.0	mAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ7201		–	2.0	
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	MJ7200		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	MJ7201		–	100	
Emitter-Base Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 80 Vdc, I_B = 0)	MJ7200		–	1.0	
(V_{CE} = 100 Vdc, I_B = 0)	MJ7201		–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)			15	–	
(I_C = 20 Adc, V_{CE} = 5.0 Vdc)			20	100	
(I_C = 40 Adc, V_{CE} = 5.0 Vdc)			12	75	
(I_C = 60 Adc, V_{CE} = 5.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.0	
(I_C = 40 Adc, I_B = 4.0 Adc)			–	1.5	
(I_C = 60 Adc, I_B = 8.0 Adc)			–	2.5	
Base-Emitter Saturation Voltage (I_C = 40 Adc, I_B = 4.0 Adc)		$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 20 Adc, V_{CE} = 5.0 Vdc)			–	1.6	
(I_C = 60 Adc, V_{CE} = 5.0 Vdc)			–	3.2	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.7 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	20	–	MHz
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 100 kHz)		C_{ob}	–	1200	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MJ8100 (SILICON)
MJ8101

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

5 AMPERE
POWER TRANSISTORS

PNP SILICON

60 - 80 VOLTS
10 WATTS



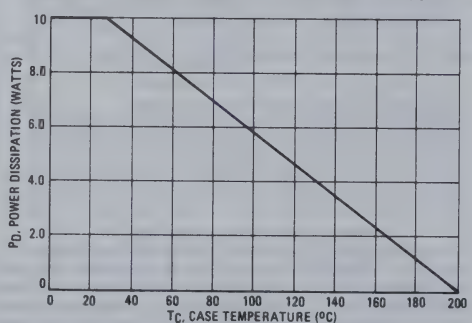
MAXIMUM RATINGS

Rating	Symbol	MJ8100	MJ8101	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57.2		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

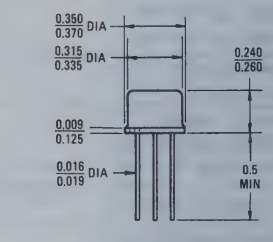
THERMAL CHARACTERISTICS

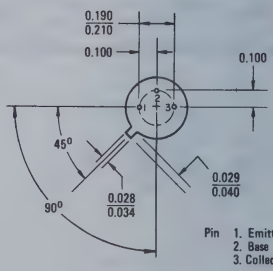
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.





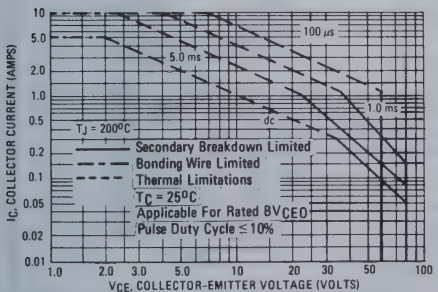
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 50 mAdc, I_B = 0)	MJ8100	$V_{CEO(sus)}$	60	–	Vdc
	MJ8101		80	–	
Collector Cutoff Current (V_{CE} = 55 Vdc, I_B = 0)	MJ8100	I_{CEO}	–	100	μAdc
(V_{CE} = 75 Vdc, I_B = 0)	MJ8101		–	100	
Collector Cutoff Current (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ8100	I_{CEX}	–	10	μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ8101		–	10	
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ8100		–	1.0	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ8101		–	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}	25	–	–
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			25	180	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{CE(sat)}$	–	0.7	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)			–	1.2	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)	t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)	t_f	–	150	ns

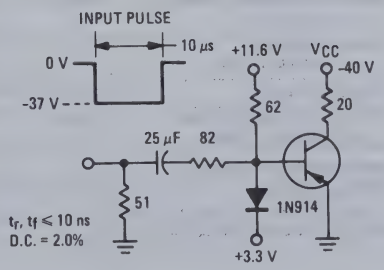
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ9000 (SILICON)

HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for single unit use in color horizontal deflection output circuits in television receivers.

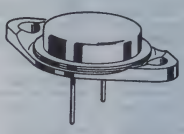
- High Collector-Emitter Voltage — V_{CES} = 700 Vdc
- Fast Fall Time — t_f = 1.1 μs (Max) @ I_C = 6.0 Adc

10 AMPERE
POWER TRANSISTOR

NPN SILICON

700 VOLTS
125 WATTS

DS 3157



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Emitter Voltage	V_{CES}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

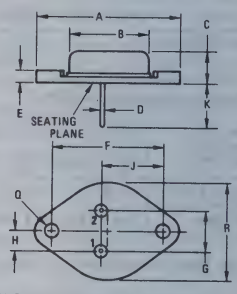
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 0.1 Adc, I_B = 0)	BV_{CEO}	325	–	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, V_{EB} = 0)	I_{CES}	–	1.0	mAdc
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 1.6 Adc)	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS				
Fall Time (See Figure 3) (V_{CC} = 80 Vdc, I_C = 6.0 Adc, I_{B1} = 1.6 Adc)	t_f	–	1.1	μs

(1) Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.



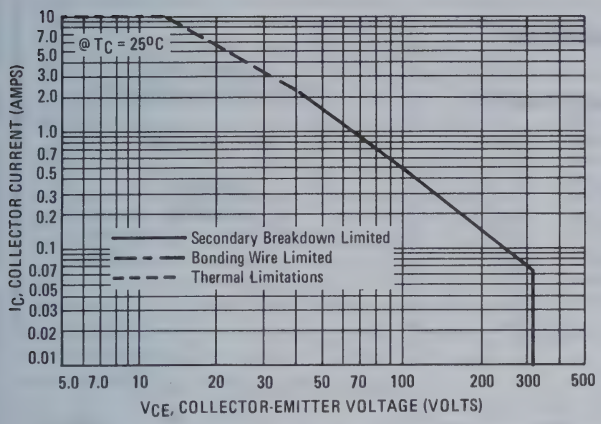
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

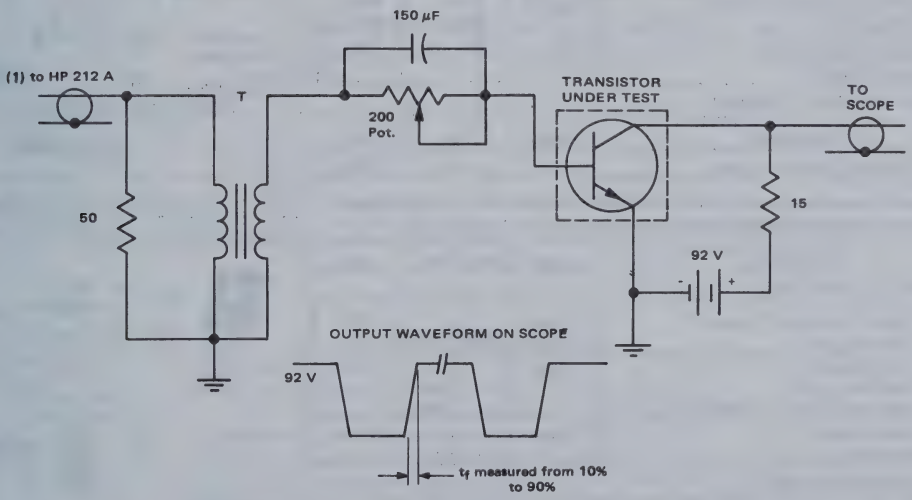
Collector connected to case.
CASE 11

FIGURE 1 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – TEST CIRCUIT FOR FALL TIME



(1) HP 212A: Set for 10 μs wide pulses at 2000 pulses per sec. (500 μs intervals). Adjust for I_{B1} = 1.6 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

MJE105 (SILICON)
MJE105K

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to NPN MJE205, MJE205K
- Choice of Packages – MJE105 – Case 90
  MJE105K – Case 199

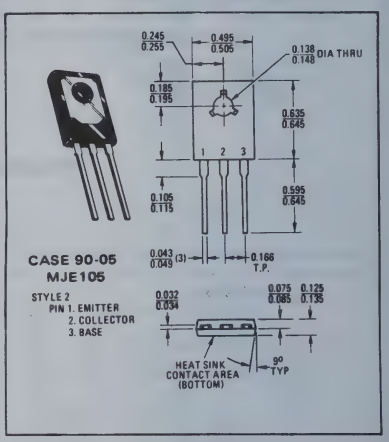
5 AMPERE
POWER TRANSISTORS

PNP SILICON

50 VOLTS
65 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D(1)	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C



THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

(1) Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	– –	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.2	Vdc

(2) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

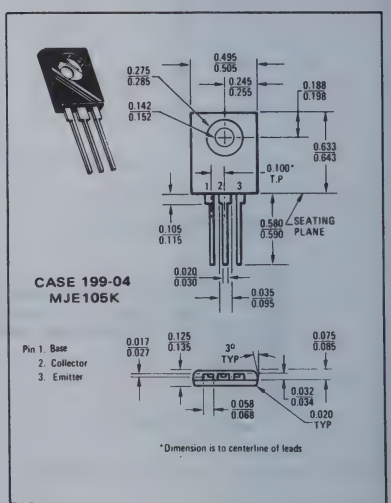
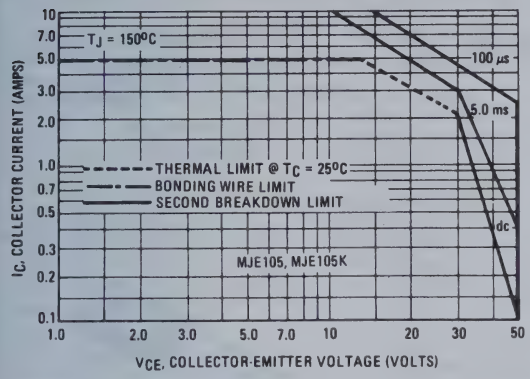


FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ ≤150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

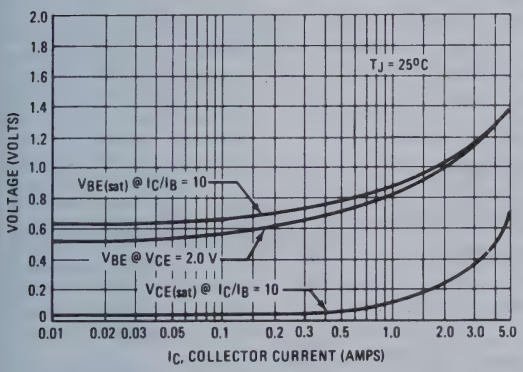


FIGURE 3 – DC CURRENT GAIN

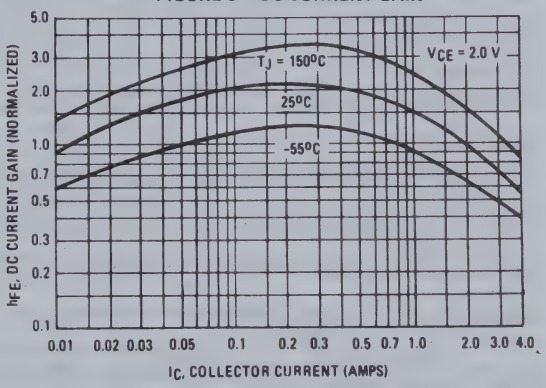
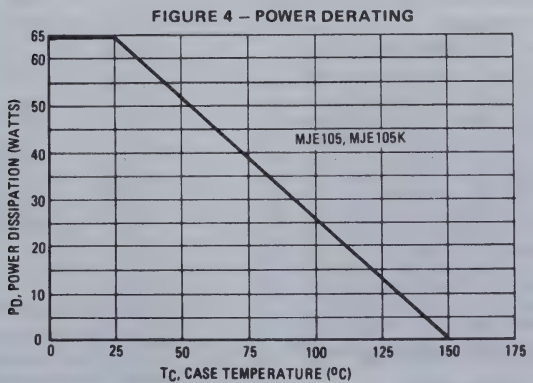


FIGURE 4 – POWER DERATING



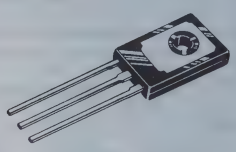
MJE170 thru MJE172 PNP (SILICON)
MJE180 thru MJE182 NPN

COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

. . . designed for low power audio amplifier and low current, high speed switching applications.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc – MJE170, MJE180
  = 60 Vdc – MJE171, MJE181
  = 80 Vdc – MJE172, MJE182
- DC Current Gain –
  h_{FE} = 30 (Min) @ I_C = 0.5 Adc
  = 12 (Min) @ I_C = 1.5 Adc
- Current-Gain – Bandwidth Product –
  f_T = 50 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakages –
  I_{CBO} = 100 nA (Max) @ Rated V_{CB}

3 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
40-60-80 VOLTS
12.5 WATTS



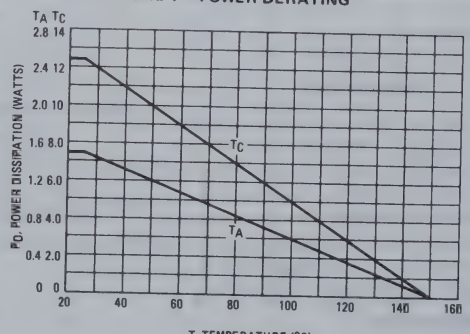
MAXIMUM RATINGS

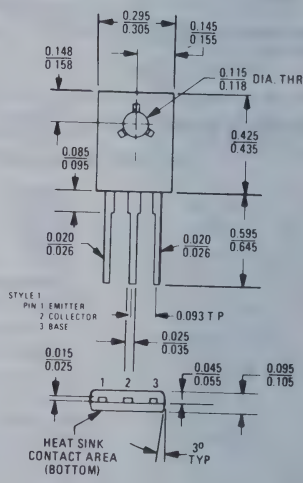
Rating	Symbol	MJE170 MJE180	MJE171 MJE181	MJE172 MJE182	Unit
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0			Vdc
Collector Current – Continuous Peak	I_C	3.0 6.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012			Watts W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	12.5 0.1			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	10	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 – POWER DERATING





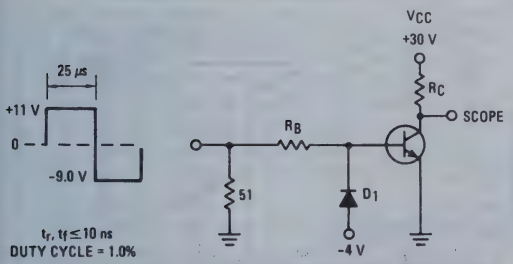
CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJE170, MJE180	$V_{CEO(sus)}$	40	–	Vdc
	MJE171, MJE181		60	–	
	MJE172, MJE182		80	–	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJE170, MJE180		–	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	MJE171, MJE181		–	0.1	
(V_{CB} = 100 Vdc, I_E = 0)	MJE172, MJE182		–	0.1	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJE170, MJE180		–	0.1	mAdc
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJE171, MJE181		–	0.1	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)	MJE172, MJE182		–	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	250	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			30	–	
(I_C = 1.5 Adc, V_{CE} = 1.0 Vdc)			12	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.3	
(I_C = 1.5 Adc, I_B = 150 mAdc)			–	0.9	
(I_C = 3.0 Adc, I_B = 600 mAdc)			–	1.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 150 mAdc)			–	1.5	
(I_C = 3.0 Adc, I_B = 600 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (1) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	50	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJE170/MJE172		–	50	
	MJE180/MJE182		–	30	

(1) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

For PNP test circuit, reverse all polarities.

FIGURE 3 – TURN-ON TIME

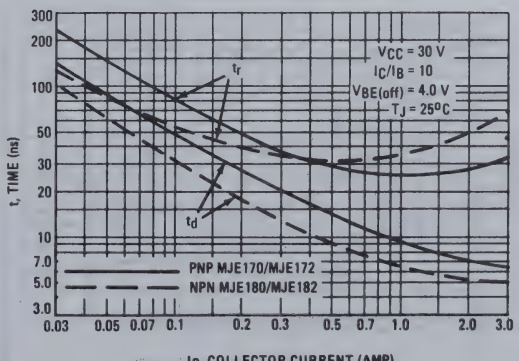
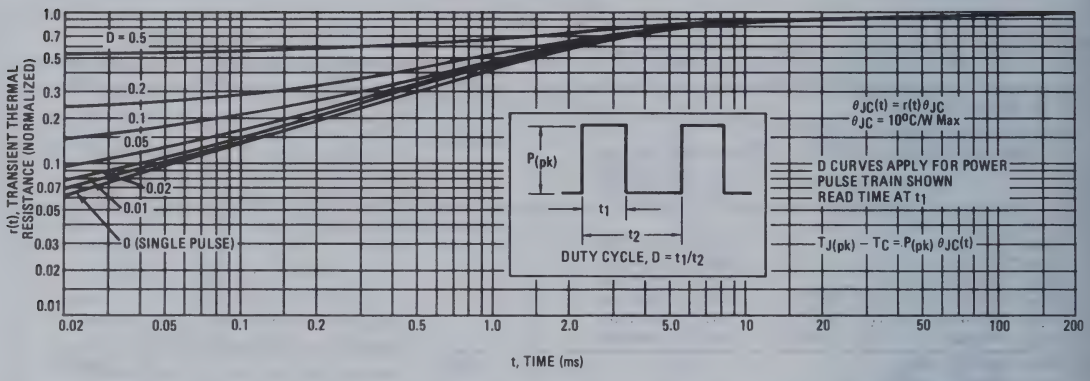


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – MJE170, MJE171, MJE172

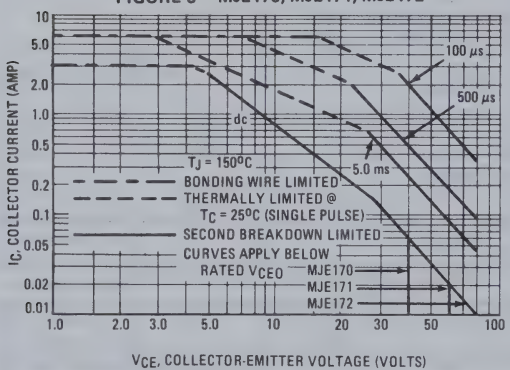
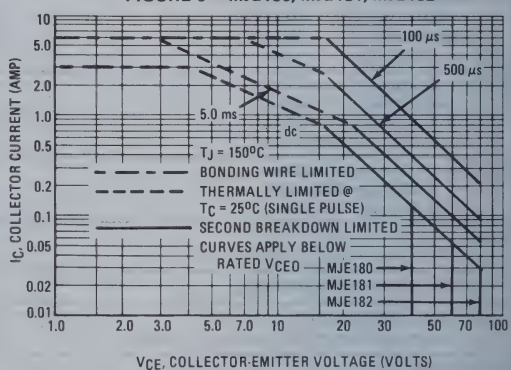


FIGURE 6 – MJE180, MJE181, MJE182



There are two limitations on the power handling ability of a transistor – average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperature, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – TURN-OFF TIME

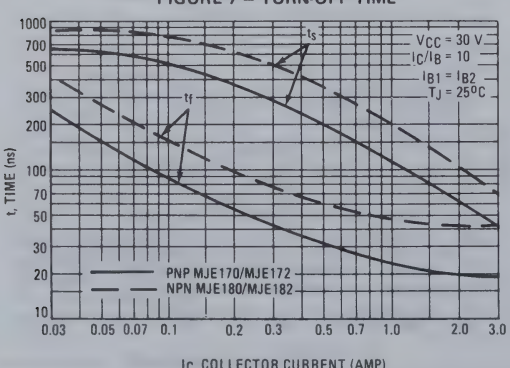
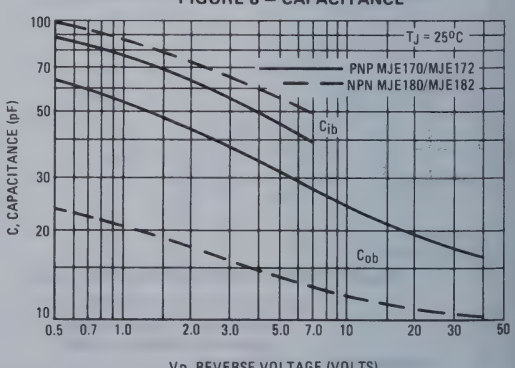


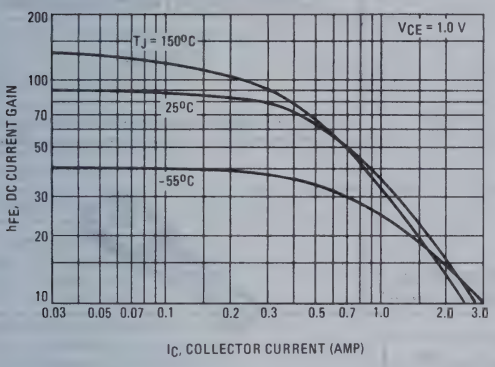
FIGURE 8 – CAPACITANCE



PNP
MJE170, MJE171, MJE172

NPN
MJE180, MJE181, MJE182

FIGURE 9 – DC CURRENT GAIN



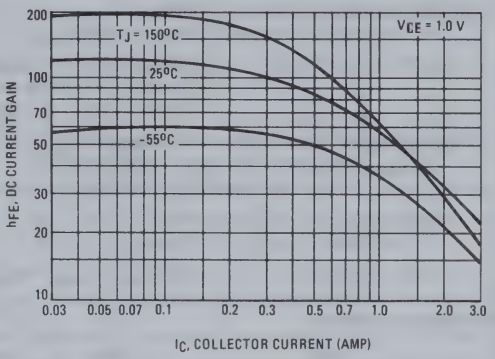
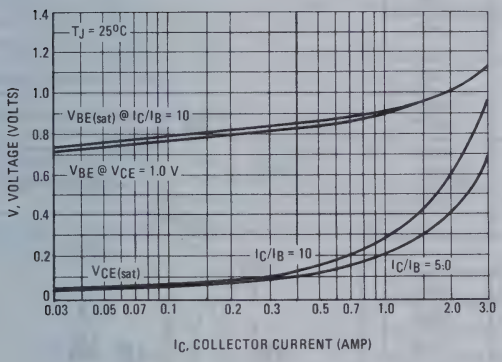


FIGURE 10 – "ON" VOLTAGES



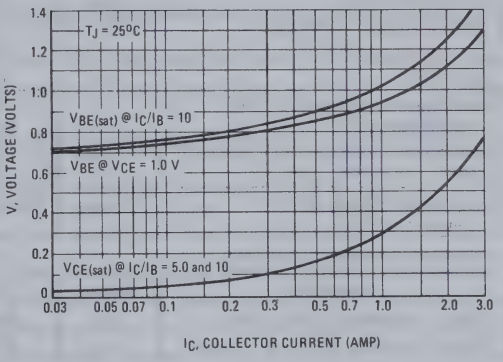
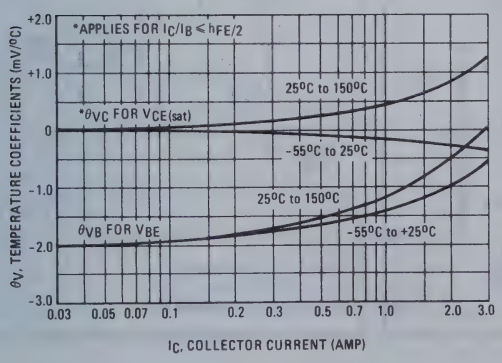
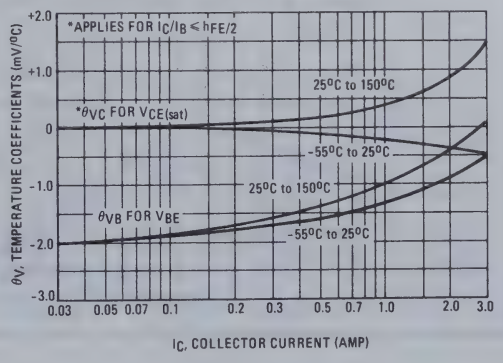


FIGURE 11 – TEMPERATURE COEFFICIENTS





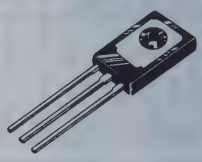
MJE200 NPN (SILICON)
MJE210 PNP

COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low voltage, low-power, high-gain audio amplifier applications.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 25 Vdc (Min) @ I_C = 10 mAdc
- High DC Current Gain – h_{FE} = 70 (Min) @ I_C = 500 mAdc
  = 45 (Min) @ I_C = 2.0 Adc
  = 10 (Min) @ I_C = 5.0 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 500 mAdc
  = 0.75 Vdc (Max) @ I_C = 2.0 Adc
- High Current-Gain – Bandwidth Product –
  f_T = 65 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakage – I_{CBO} =100 nAdc@ Rated V_{CB}

5 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
25 VOLTS
15 WATTS



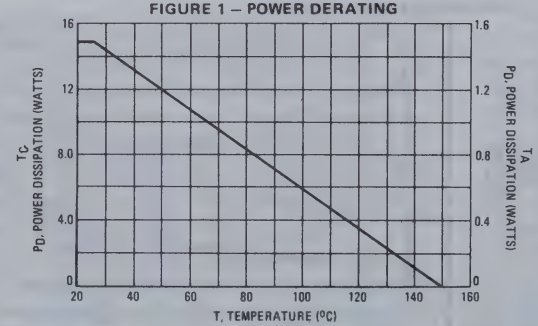
MAXIMUM RATINGS

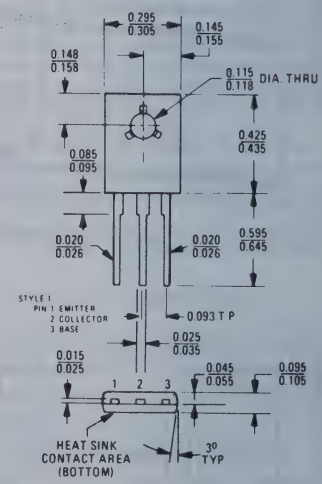
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current – Continuous Peak	I_C	5.0 10	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12	Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 – POWER DERATING





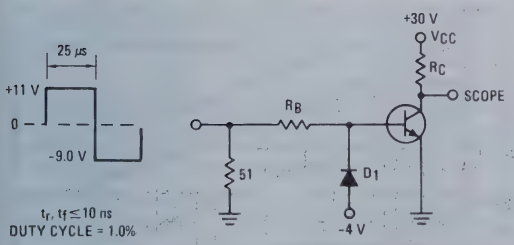
CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	25	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_J = 125°C)	I_{CBO}	– –	100 100	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 1.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	 70 45 10	 – 180 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 2.0 Adc, I_B = 200 mAdc) (I_C = 5.0 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	 – – –	 0.3 0.75 1.8	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 5.0 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	–	2.5	Vdc
Base-Emitter On Voltage (1) (I_C = 2.0 Adc, V_{CE} = 1.0 Vdc	$V_{BE(on)}$	–	1.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)	f_T	65	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz) MJE200 MJE210	C_{ob}	 – –	 80 120	pF

(1) Pulse test: Pulse Width = 300 μs, Duty Cycle ≈ 2.0%.
(2) $f_T = |h_{fe}| \cdot f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

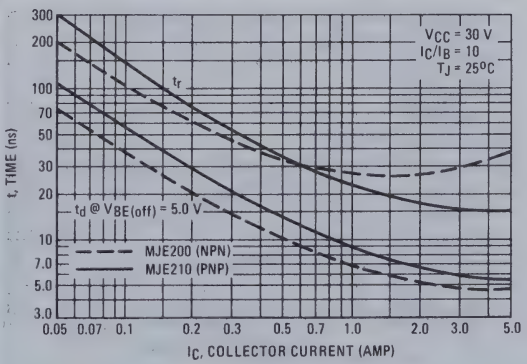


FIGURE 4 – THERMAL RESPONSE

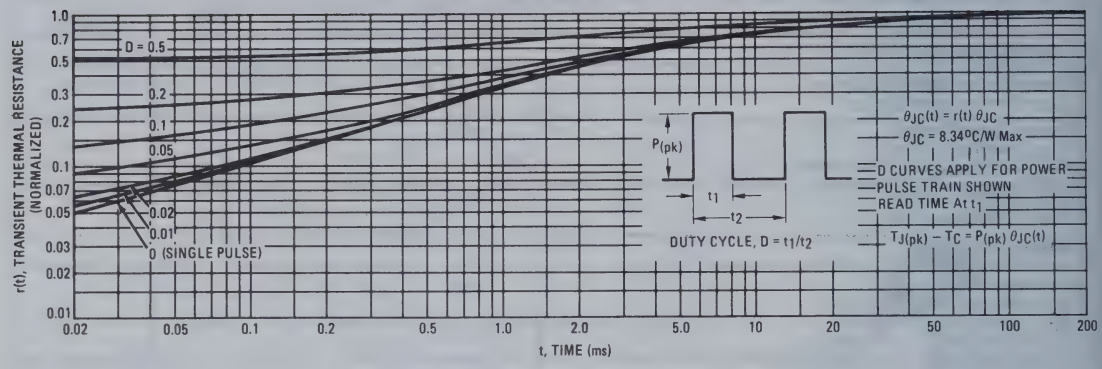
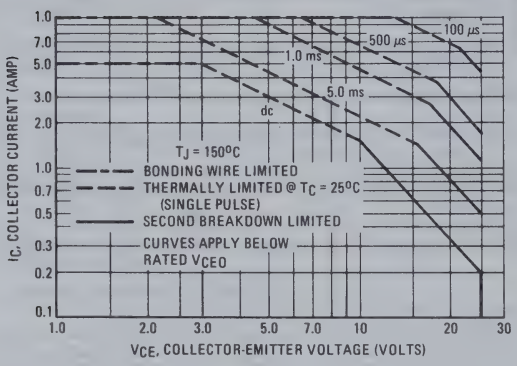


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

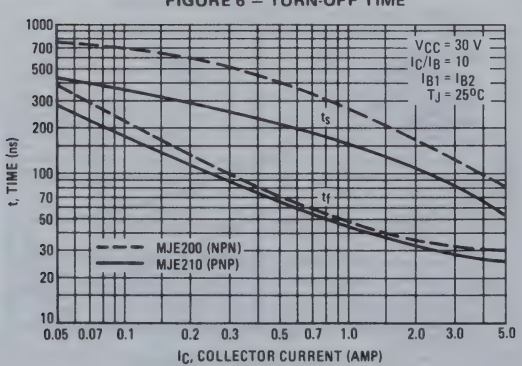
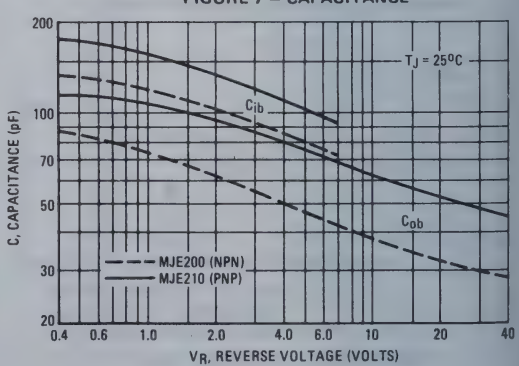


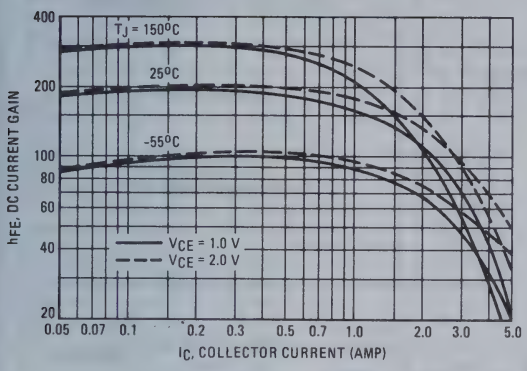
FIGURE 7 – CAPACITANCE



NPN
MJE200

PNP
MJE210

FIGURE 8 – DC CURRENT GAIN



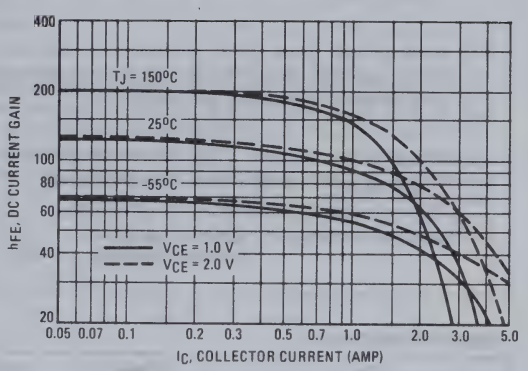
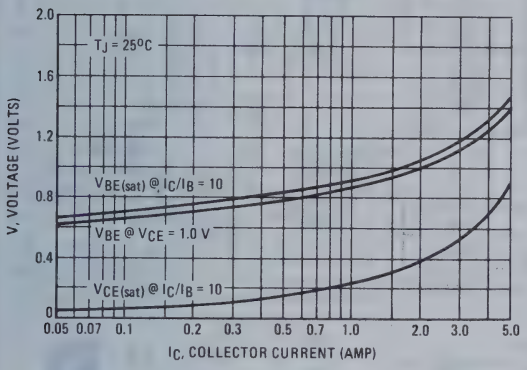


FIGURE 9 – "ON" VOLTAGE



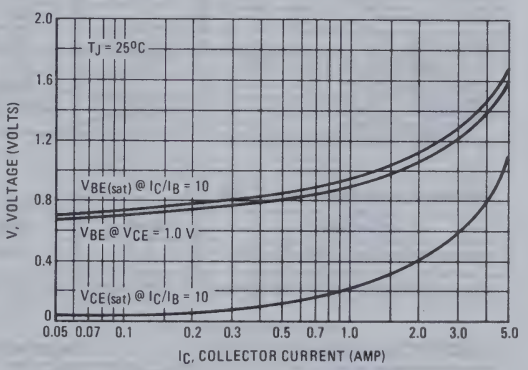
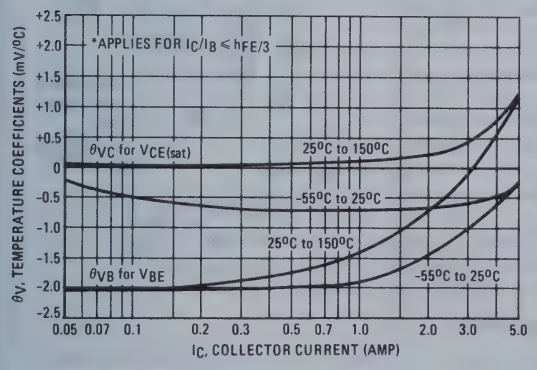
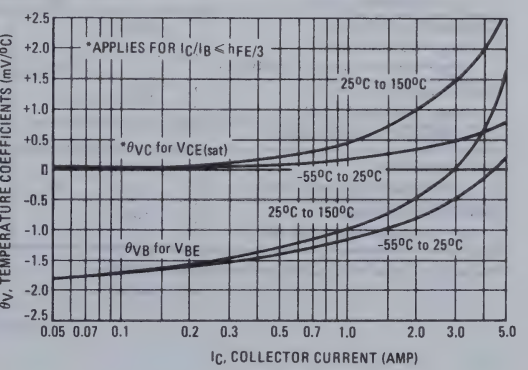


FIGURE 10 – TEMPERATURE COEFFICIENTS





MJE205 (SILICON)
MJE205K

MEDIUM-POWER NPN SILICON TRANSISTORS

. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain — h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad ▲ High-Efficiency Compact Package
- Complementary to PNP MJE 105, MJE105K
- Choice of Packages — MJE205-Case 90
  MJE205K-Case 199

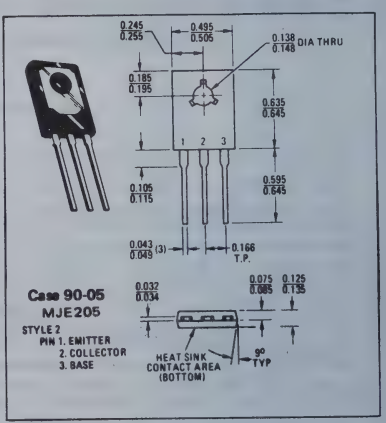
5 AMPERE POWER TRANSISTORS

NPN SILICON

50 VOLTS
65 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C=25°C Derate above 25°C	P_D†	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C



THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage‡ (I_C = 100 mAdc, I_B = 0)	BV_{CEO}‡	50	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C=150°C)	I_{CBO}	– –	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.2	Vdc

‡Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

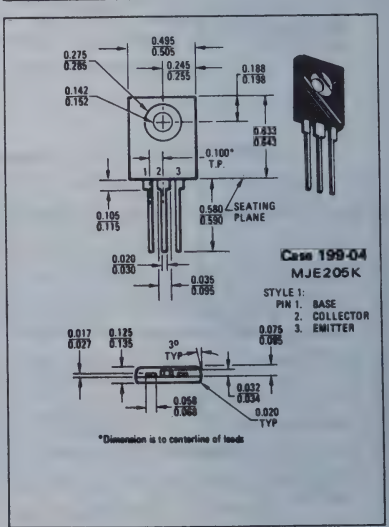
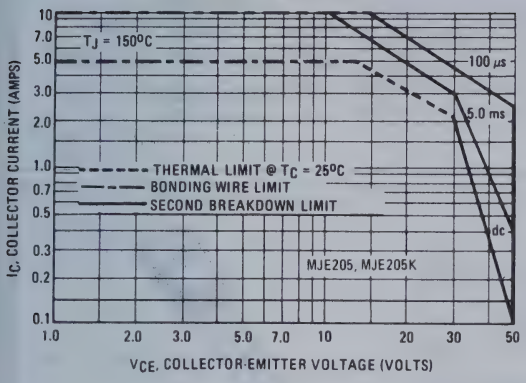


FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

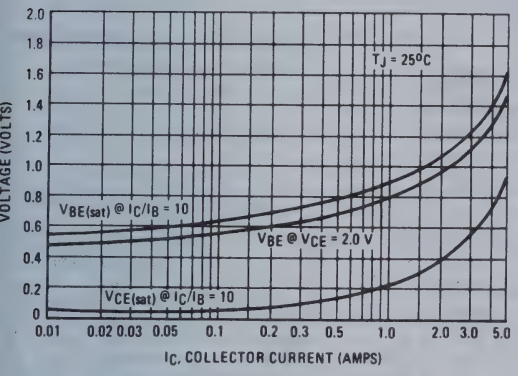


FIGURE 3 – DC CURRENT GAIN

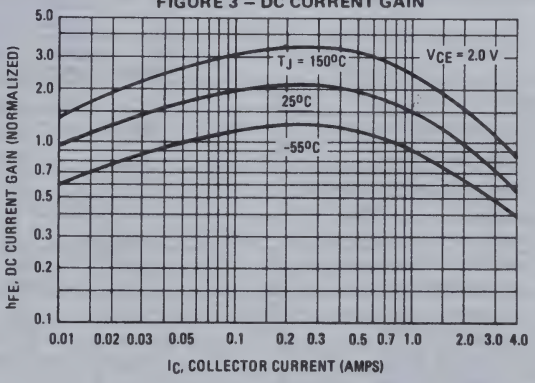
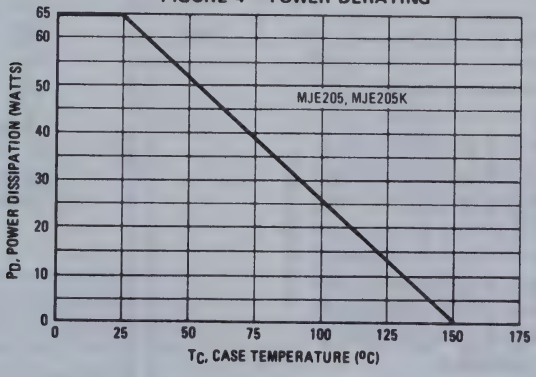


FIGURE 4 – POWER DERATING



MJE220 thru MJE225 NPN (SILICON)
MJE230 thru MJE235 PNP

COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

. . . designed for low power audio amplifier and low current, high-speed switching applications.

- Low Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) – MJE220/MJE222
  MJE230/MJE232
  = 60 Vdc (Min) – MJE223/MJE225
  MJE233/MJE235
- High Current-Gain – Bandwidth Product –
  f_T = 50 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakage –
  I_{CBO} = 100 nAdc (Max) @ Rated V_{CB}
- DC Current Gain Specified at 200 mAdc and 1.0 or 2.0 Adc
- Collector-Emitter Saturation Voltage Specified at 500 mAdc and 1.0, 2.0 and 4.0 Adc.

4 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

40, 60 VOLTS
15 WATTS



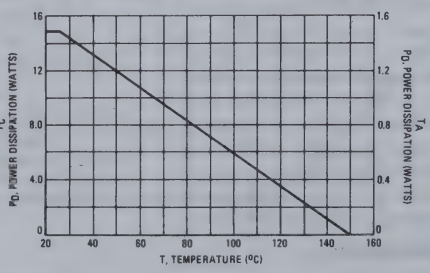
MAXIMUM RATINGS

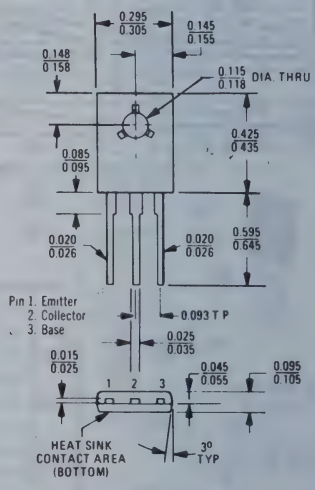
Rating	Symbol	MJE220 MJE221 MJE222 MJE230 MJE231 MJE232	MJE223 MJE224 MJE225 MJE233 MJE234 MJE235	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current – Continuous Peak	I_C	4.0 8.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	–65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 – POWER DERATING



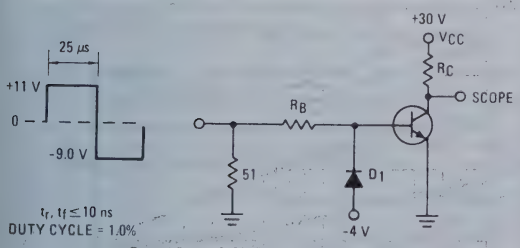


CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232	$V_{CEO(sus)}$	40	–	Vdc
	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		60	–	
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232	I_{CBO}	–	0.1	μAdc
(V_{CB} = 80 Vdc, I_E = 0)	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		–	0.1	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 125°C)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232		–	0.1	mAdc
(V_{CB} = 80 Vdc, I_E = 0, T_C = 125°C)	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		–	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	MJE220,MJE230, MJE223,MJE233	h_{FE}	40	200	–
	MJE221,MJE231, MJE224,MJE234		40	150	
	MJE222,MJE232, MJE225,MJE235		25	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MJE221,MJE231, MJE224,MJE234		20	–	
	MJE222,MJE232, MJE225,MJE235		10	–	
(I_C = 2.0 Adc, V_{CE} = 1.0 Vdc)	MJE220,MJE230, MJE223,MJE233		20	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	–	0.3	Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)	MJE221, MJE231, MJE224, MJE234		–	0.6	
(I_C = 2.0 Adc, I_B = 200 mAdc)	MJE220, MJE230, MJE223, MJE233		–	0.8	
(I_C = 4.0 Adc, I_B = 1.0 Adc)	All Types		–	2.5	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$	–	1.8	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJE220/MJE225	C_{ob}	–	50	pF
	MJE230/MJE235		–	70	

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx$ 100 mA
MSD6100 USED BELOW $I_B \approx$ 100 mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

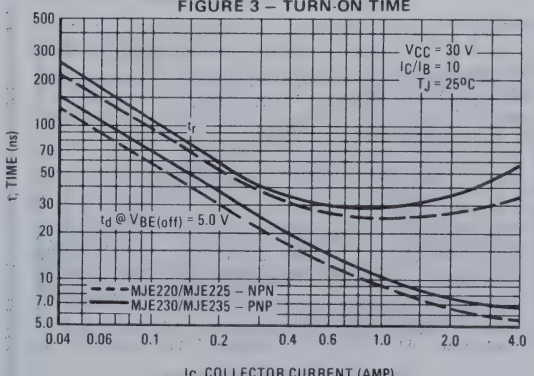


FIGURE 4 – THERMAL RESPONSE

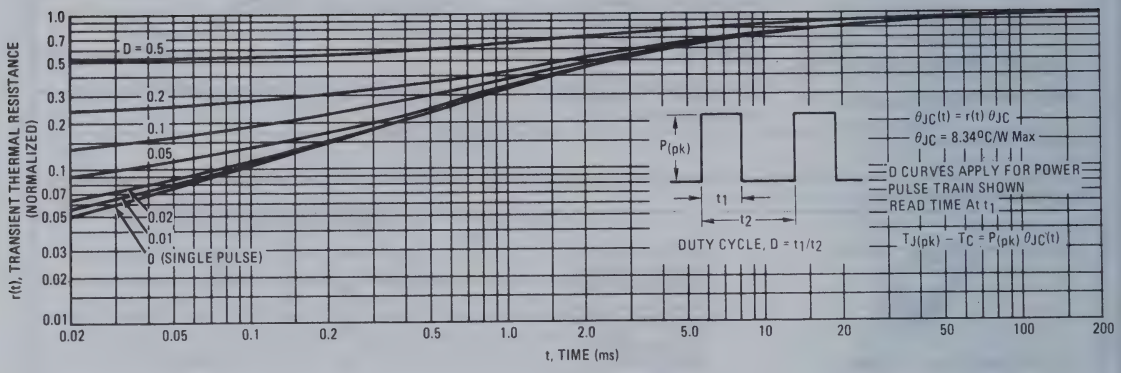
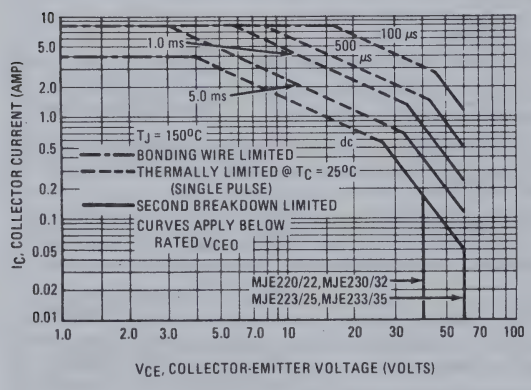


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

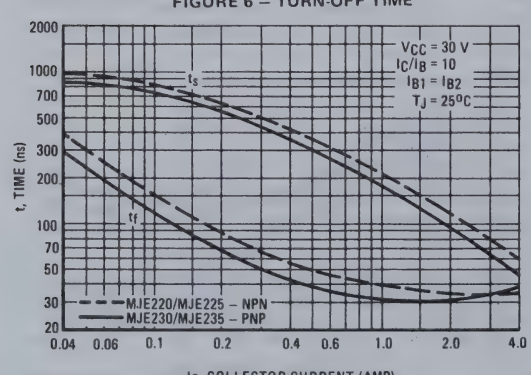
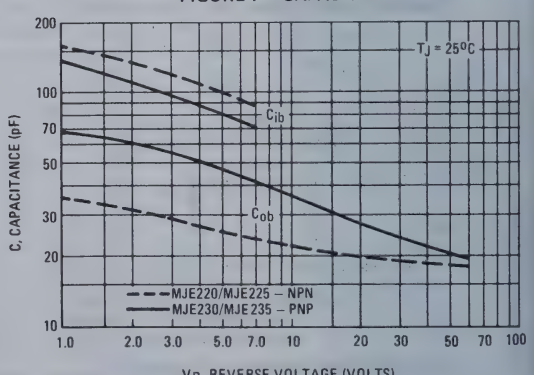


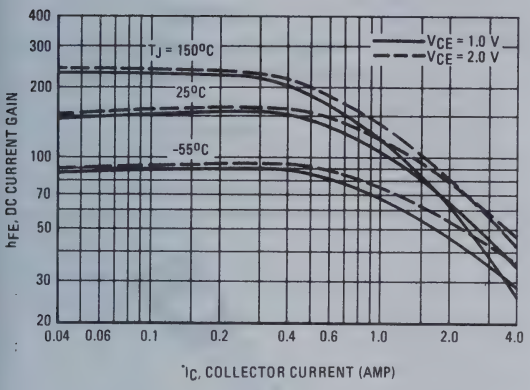
FIGURE 7 – CAPACITANCE



NPN
MJE220 thru MJE225

PNP
MJE230 thru MJE235

FIGURE 8 – DC CURRENT GAIN



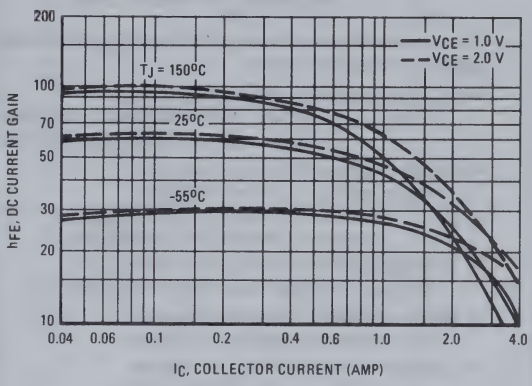
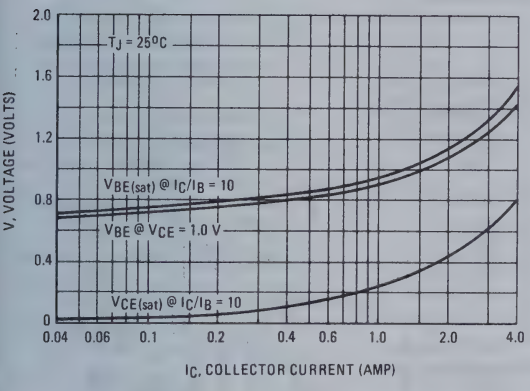


FIGURE 9 – "ON" VOLTAGES



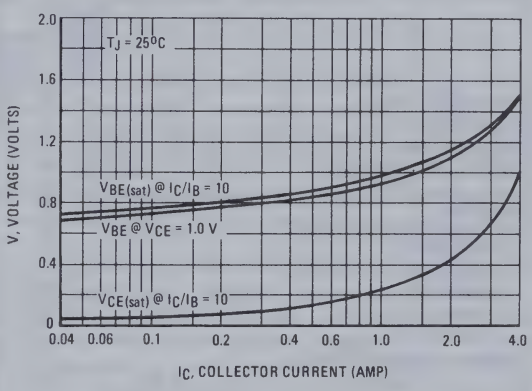
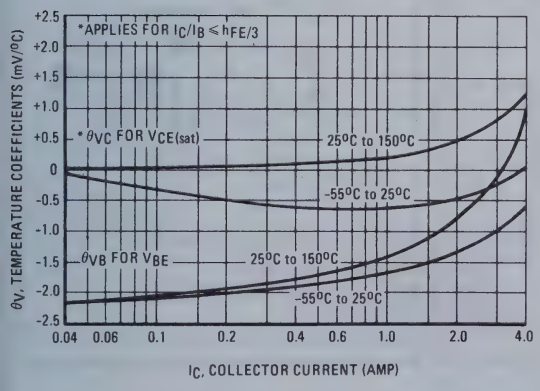
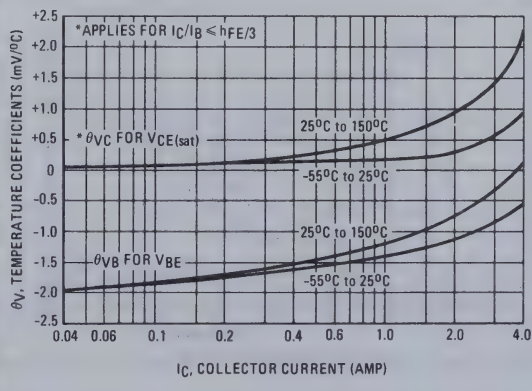


FIGURE 10 – TEMPERATURE COEFFICIENTS





MJE240 thru MJE244 NPN (SILICON)
MJE250 thru MJE254 PNP

COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low power audio amplifier and low-current, high-speed switching applications.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 80 Vdc (Min) – MJE240/2, MJE250/2
  = 100 Vdc (Min) – MJE243/4, MJE253/4
- High DC Current Gain @ I_C = 200 mAdc
  h_{FE} = 40-200 – MJE240, MJE250
  = 40-120 – MJE241,243, MJE251,253
  = 25 (Min) – MJE242,44, MJE252,54
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 500 mAdc
- High Current Gain Bandwidth Product –
  f_T = 40 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakages
  I_{CBO} = 100 nAdc (Max) @ Rated V_{CB}

4 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
80, 100 VOLTS
15 WATTS



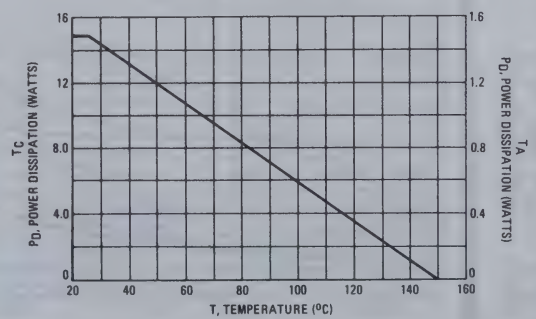
MAXIMUM RATINGS

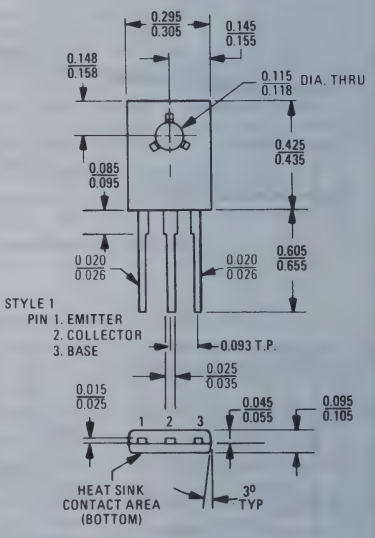
Rating	Symbol	MJE240 MJE241 MJE242 MJE250 MJE251 MJE252	MJE243 MJE244 MJE253 MJE254	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current – Continuous Peak	I_C	4.0 8.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 – POWER DERATING



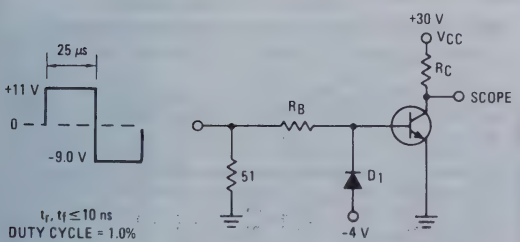


CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJE240,MJE241,MJE242, MJE250,MJE251,MJE252	$V_{CEO(sus)}$	80	–	Vdc
	MJE243,MJE244 MJE253,MJE254		100	–	
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	MJE240,MJE241,MJE242, MJE250,MJE251,MJE252	I_{CBO}	–	0.1	μAdc
(V_{CB} = 100 Vdc, I_E = 0)	MJE243,MJE244, MJE253,MJE254,		–	0.1	
(V_{CE} = 80 Vdc, I_E = 0, T_C = 125°C)	MJE240,MJE241,MJE242 MJE250,MJE251,MJE252,		–	0.1	mAdc
(V_{CE} = 100 Vdc, I_E = 0, T_C = 125°C)	MJE243,MJE244 MJE253,MJE254		–	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	MJE240,MJE250	h_{FE}	40	200	–
	MJE241,MJE251, MJE243,MJE253		40	120	
	MJE242,MJE252, MJE244,MJE254		25	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MJE241,MJE251, MJE243,MJE253		20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MJE242,MJE252 MJE244,MJE254		10	–	
(I_C = 2.0 Adc, V_{CE} = 1.0 Vdc)	MJE240,MJE250		15	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	–	0.3	Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)	MJE241,MJE251, MJE243,MJE253		–	0.6	
(I_C = 2.0 Adc, I_B = 200 mAdc)	MJE240, MJE250		–	0.8	
(I_C = 4.0 Adc, I_B = 0.8 Adc)	All Types		–	2.5	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$	–	1.8	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	40	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJE240/MJE244	C_{ob}	–	50	pF
	MJE250/MJE254		–	70	

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx$100 mA
MSD6100 USED BELOW $I_B \approx$100 mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

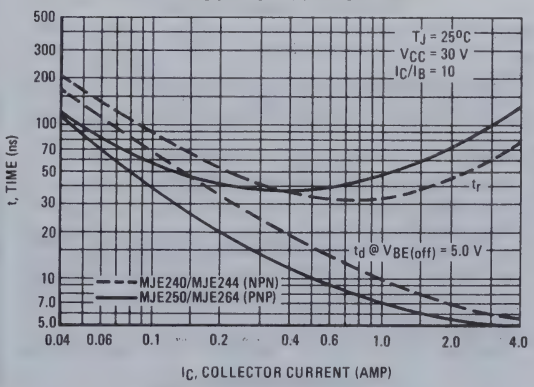


FIGURE 4 – THERMAL RESPONSE

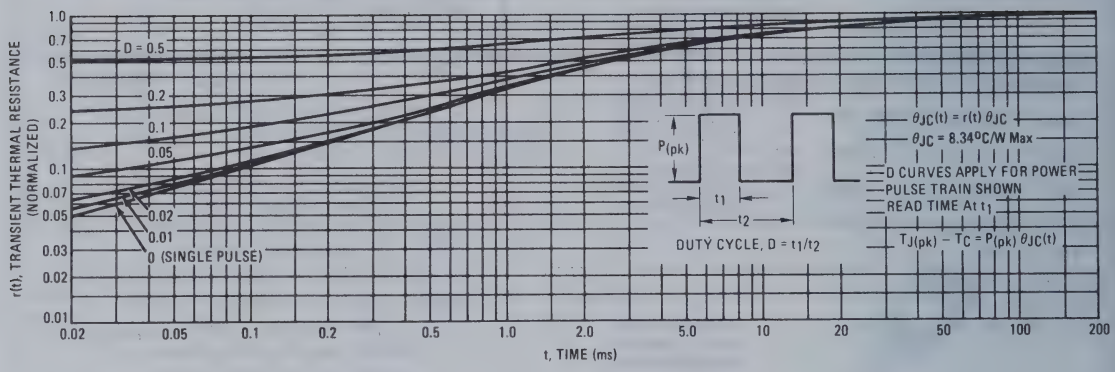
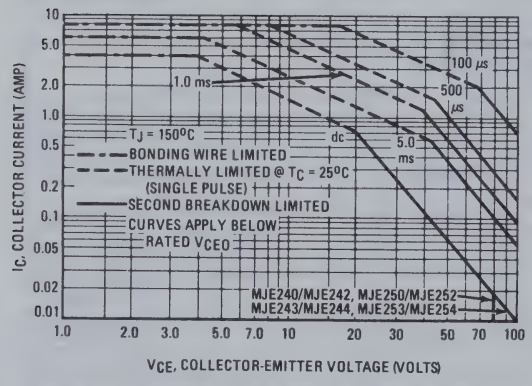


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

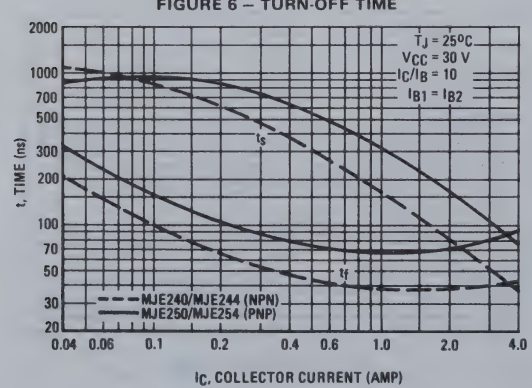
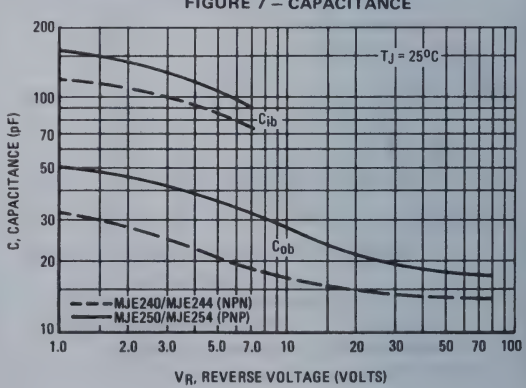


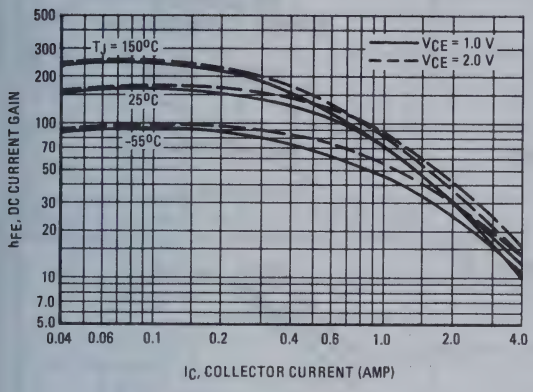
FIGURE 7 – CAPACITANCE



NPN
MJE240 thru MJE244

PNP
MJE250 thru MJE254

FIGURE 8 – DC CURRENT GAIN



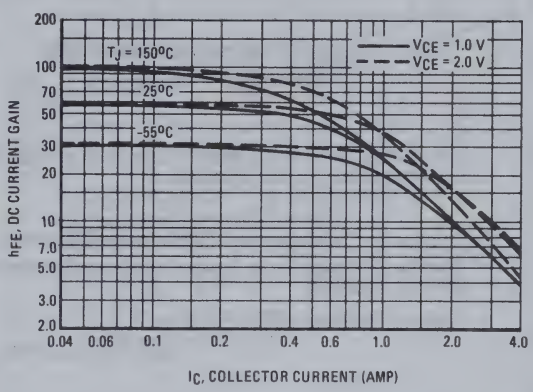
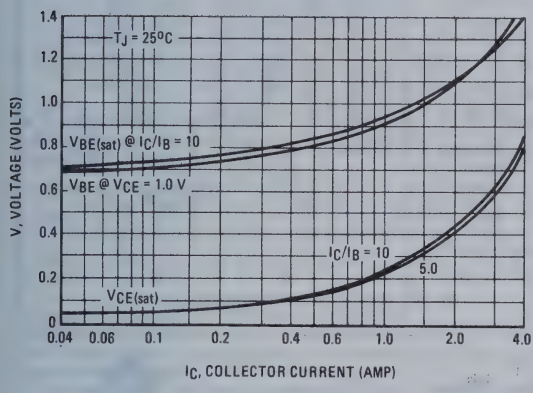


FIGURE 9 – "ON" VOLTAGES



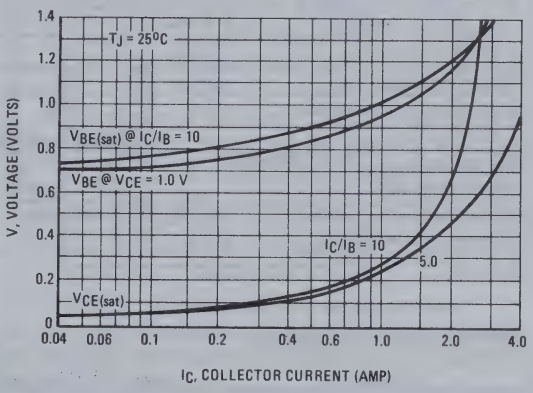
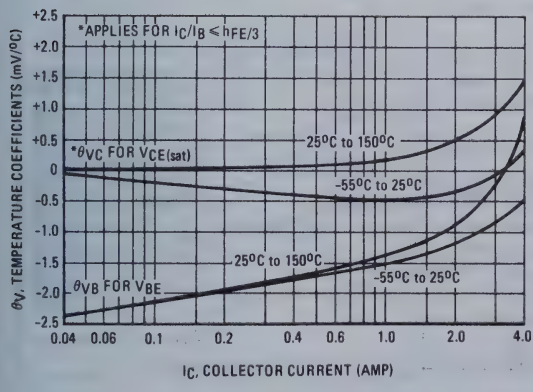
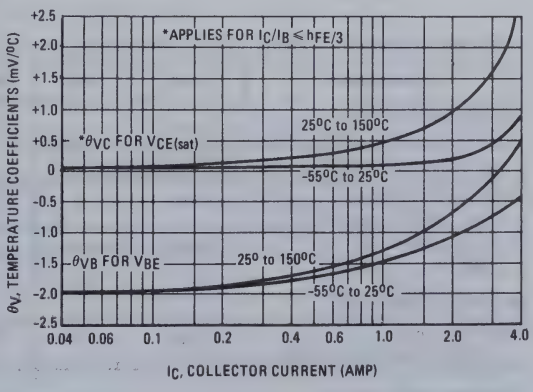


FIGURE 10 – TEMPERATURE COEFFICIENTS





MJE340 (SILICON)
MJE340K

PLASTIC MEDIUM POWER NPN SILICON TRANSISTOR

. . . designed for power output stages for television, radio, phonograph and other consumer product applications.

- Suitable for Transformerless, Line-Operated Equipment
- Thermopad ▲Construction Provides High Power Dissipation Rating for High Reliability
- Choice of Packages — MJE340 — Case 77
  MJE340K — Case 199

0.5 AMPERE POWER TRANSISTOR

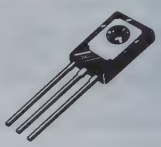
NPN SILICON

300 VOLTS
20.8 and 30 WATTS

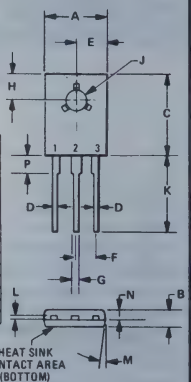
DS 3160 R1

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	300		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		MJE340	MJE340K	
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20.8 0.167	30 0.24	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150		^oC



MJE340



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.295	0.305	7.490	7.750
B	0.095	0.105	2.410	2.670
C	0.425	0.435	10.800	11.050
D	0.020	0.026	0.508	0.660
E	0.145	0.155	3.680	3.940
F	0.093 TP		2.360 TP	
G	0.025	0.035	0.635	0.889
H	0.148	0.158	3.760	4.010
J	0.115	0.118	2.920	3.000
K	0.595	0.645	15.110	16.380
L	0.015	0.025	0.381	0.635
M	3° TYP		3° TYP	
N	0.045	0.055	1.140	1.400
P	0.085	0.095	2.160	2.410

PIN 1. EMITTER
2. COLLECTOR
3. BASE

HEAT SINK CONTACT AREA (BOTTOM)

CASE 77-03

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE340	MJE340K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	4.167	$^oC/W$

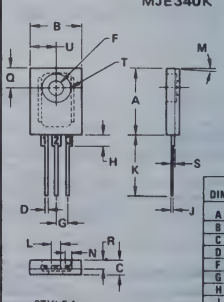
ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	–	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	240	–

▲Trademark of Motorola Inc.

MJE340K





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

NOTES:
1. DIM "G" IS TO CENTER OF LEADS

CASE 199-04

FIGURE 1 – POWER TEMPERATURE DERATING

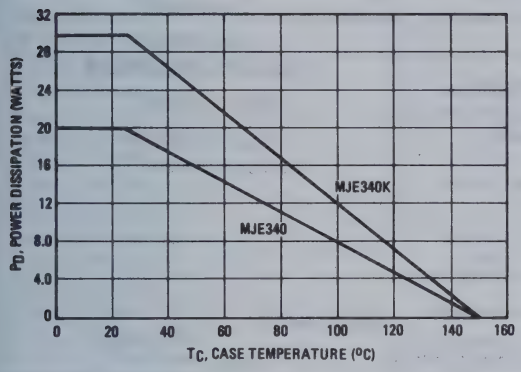
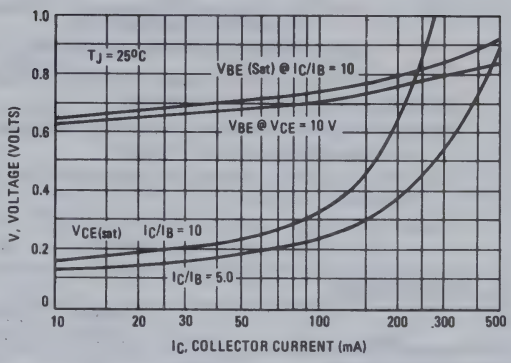


FIGURE 2 – "ON" VOLTAGES



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 3 – MJE340

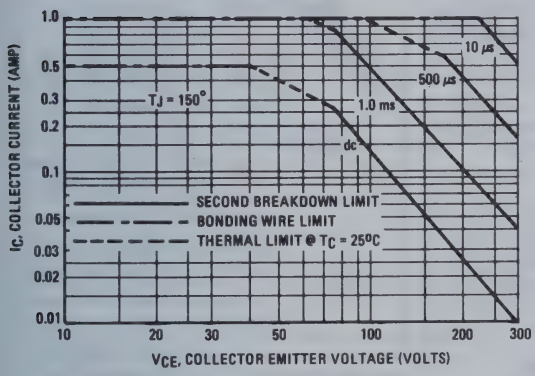
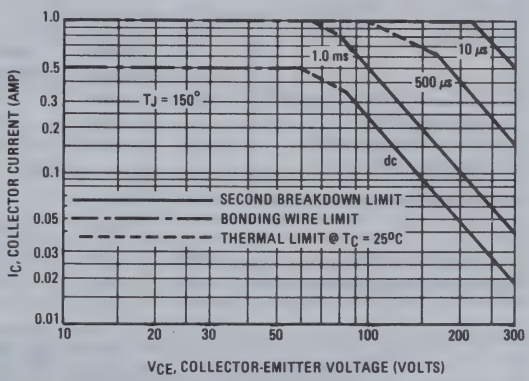


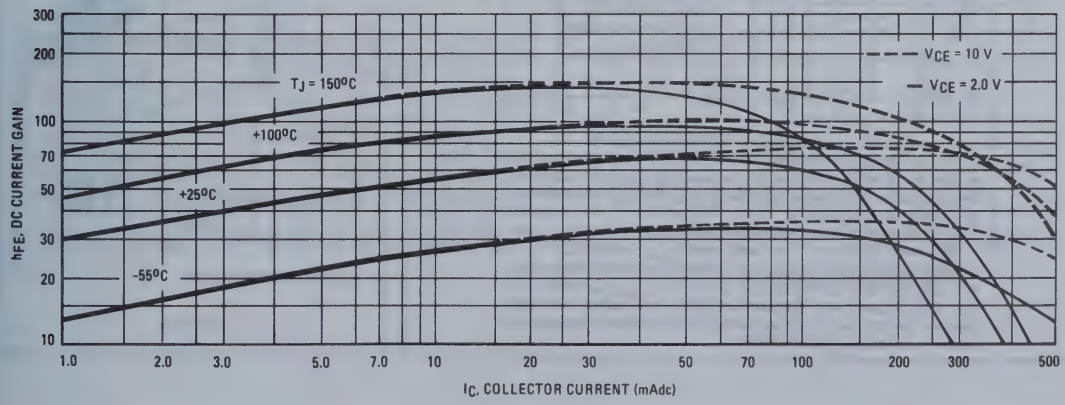
FIGURE 4 – MJE340K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 3 and 4 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (Seee AN-415)

FIGURE 5 – DC CURRENT GAIN



MJE341 MJE341K (SILICON)
MJE344 MJE344K

PLASTIC NPN SILICON
MEDIUM-POWER TRANSISTORS

. . . designed for power output stages in television, radio, phonograph and other consumer product applications.

- Recommended for 1.5 W Class A Output in Transformer Coupled, Line-Operated Equipment – MJE341
- Ideal for Audio Output Circuitry in Black and White Television Receivers – MJE344
- Choice of Packages – MJE341, MJE344 – Case 77
  MJE341K, MJE344K – Case 199

0.5 AMPERE
POWER TRANSISTORS
NPN SILICON
150-200 VOLTS
20.8 and 30 WATTS

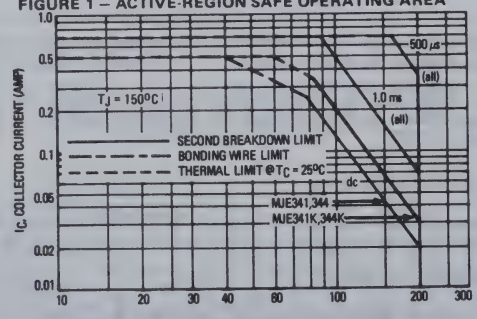
MAXIMUM RATINGS

Rating	Symbol	MJE341 MJE341K	MJE344 MJE344K	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	175	200	Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Collector Current – Continuous	I_C	← 500 →		mAdc
Base Current	I_B	← 250 →		mAdc
		MJE341 MJE344	MJE341K MJE344K	
Total Device Dissipation @ T_C=25°C Derate above 25°C	P_D	20.8 0.167	30 0.24	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← −65 to +150 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE341 MJE344	MJE341K MJE344K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	4.167	°C/W

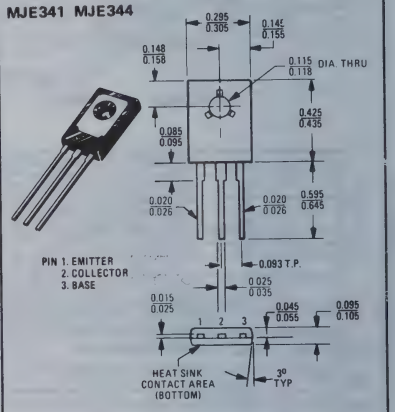
FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

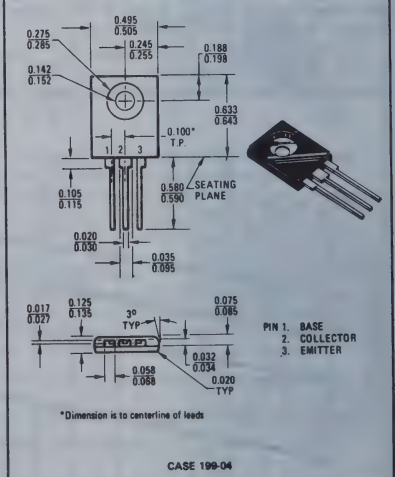
The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJE341 MJE344



CASE 77-03

MJE341K MJE344K



CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	MJE341,K MJE344,K	$V_{CEO(sus)}$	 150 200	 – –	Vdc
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	MJE341,K		–	1.0	
(V_{CE} = 200 Vdc, I_B = 0)	MJE344,K		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 175 Vdc, I_E = 0)	MJE341,K		–	0.3	
(V_{CB} = 200 Vdc, I_E = 0)	MJE344,K		–	0.1	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	MJE341,K		–	0.1	
(V_{EB} = 5.0 Vdc, I_C = 0)	MJE344,K		–	0.1	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MJE341,K		20	–	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJE341,K		25	200	
	MJE344,K		30	300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MJE341,K		20	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		–	1.0	
(I_C = 150 mAdc, I_B = 15 mAdc)	MJE341,K		–	2.3	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – DC CURRENT GAIN

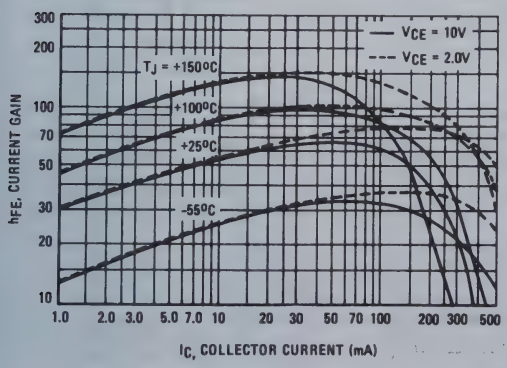
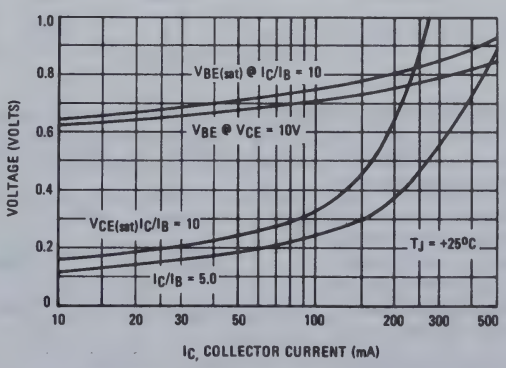


FIGURE 3 – "ON" VOLTAGES



MJE350 (SILICON)

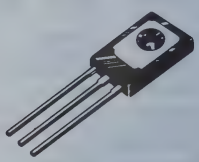
PLASTIC MEDIUM POWER PNP SILICON TRANSISTOR

. . . designed for use in line-operated audio and television applications and as low power, line-operated series pass and switching regulators.

- High Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 300 Vdc @ I_C = 1.0 mAdc
- Excellent DC Current Gain — h_{FE} = 30-240 @ I_C = 50 mAdc
- Plastic Thermopad Package

0.5 AMPERE POWER TRANSISTOR PNP SILICON

300 VOLTS 20 WATTS



MAXIMUM RATINGS

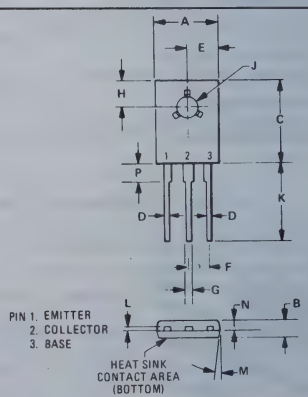
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.16	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	—	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	100	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	240	—



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.295	0.305	7.490	7.750
B	0.095	0.105	2.410	2.670
C	0.425	0.435	10.800	11.050
D	0.020	0.026	0.508	0.660
E	0.145	0.155	3.680	3.940
F	0.093 TP		2.360 TP	
G	0.025	0.035	0.635	0.889
H	0.148	0.158	3.760	4.010
J	0.115	0.118	2.920	3.000
K	0.595	0.645	15.110	16.380
L	0.015	0.025	0.381	0.635
M	3° TYP		3° TYP	
N	0.045	0.055	1.140	1.400
P	0.085	0.095	2.160	2.410

CASE 77-03

FIGURE 1 – DC CURRENT GAIN

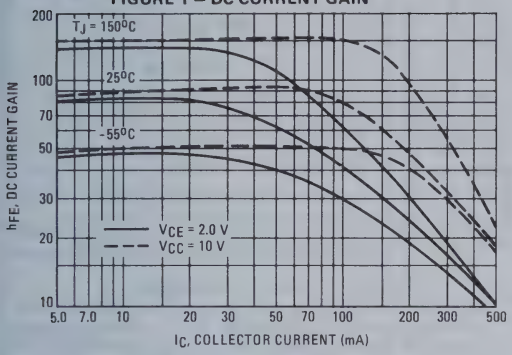


FIGURE 2 – "ON" VOLTAGES

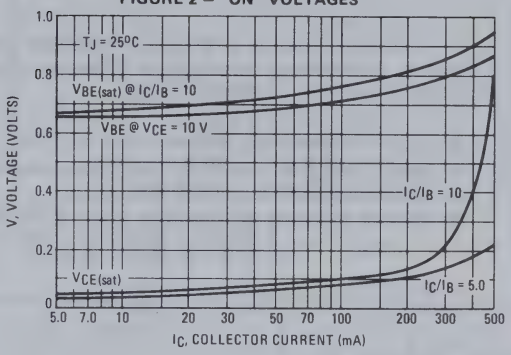


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA

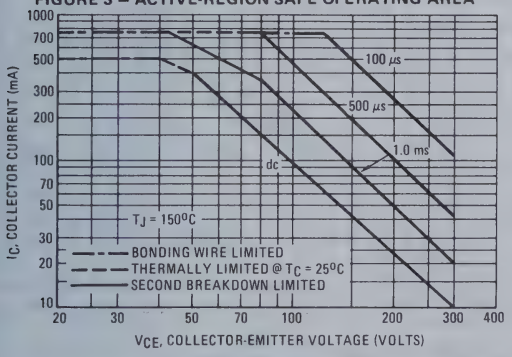
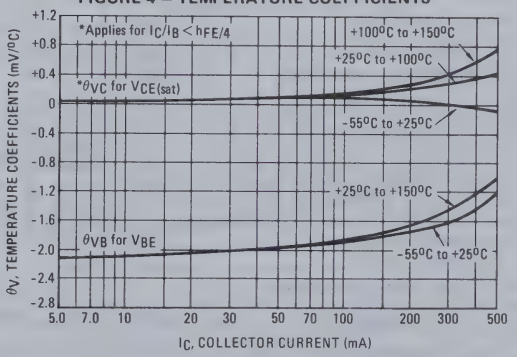


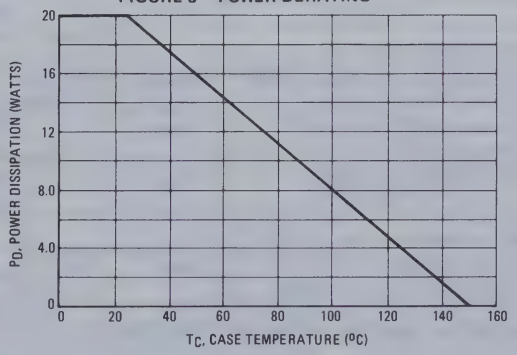
FIGURE 4 – TEMPERATURE COEFFICIENTS



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 5 – POWER DERATING



MJE370 (SILICON)
MJE370K
MJE3370

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTORS

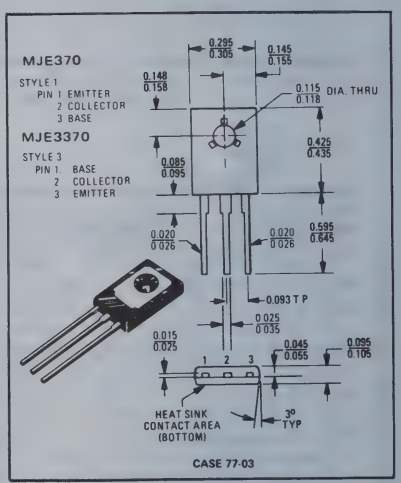
. . . designed for use in general-purpose amplifiers and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain – h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE370, MJE370K and MJE3370 are Complementary with NPN MJE520, MJE520K and MJE3520
- Choice of Packages – MJE370, 25 W – Case 77 (E-C-B), MJE3370, 25 W – Case 77 (B-C-E) MJE370K, 40 W – Case 199

3 AMPERE POWER TRANSISTORS

PNP SILICON

30 VOLTS
25 and 40 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
– Peak		7.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE370 MJE3370	MJE370K	
Total Device Dissipation @ T_C = 25°C	P_D	25	40	Watts
Derate above 25°C		0.2	0.32	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

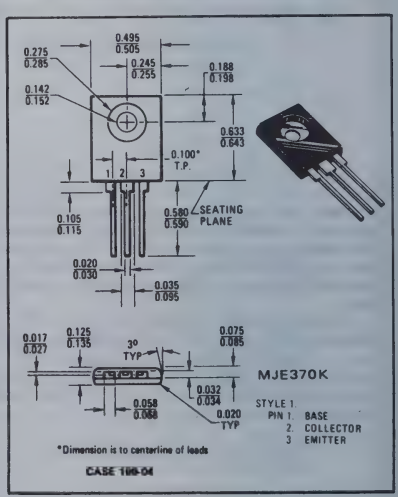
THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE370 MJE3370	MJE370K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	3.125	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

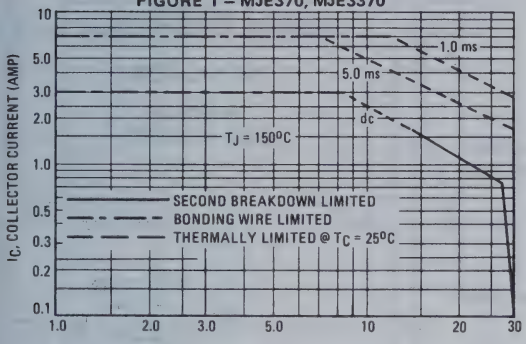
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



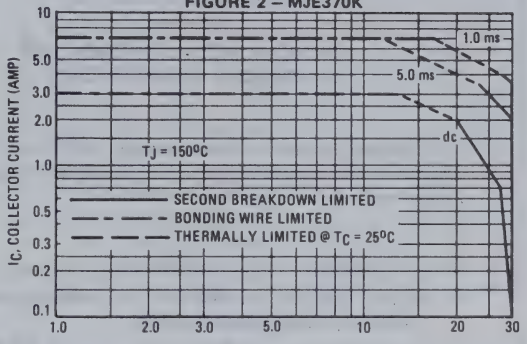
ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE370, MJE3370



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

FIGURE 2 – MJE370K



The data of Figures 1 and 2 based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

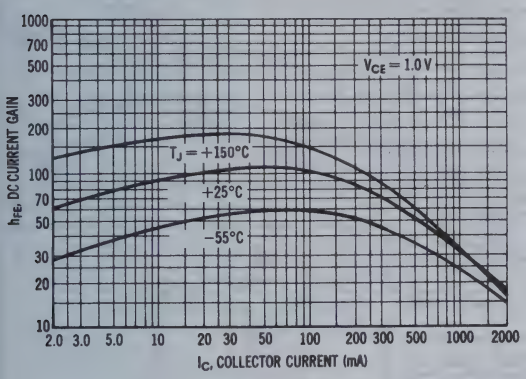


FIGURE 4 – "ON" VOLTAGE

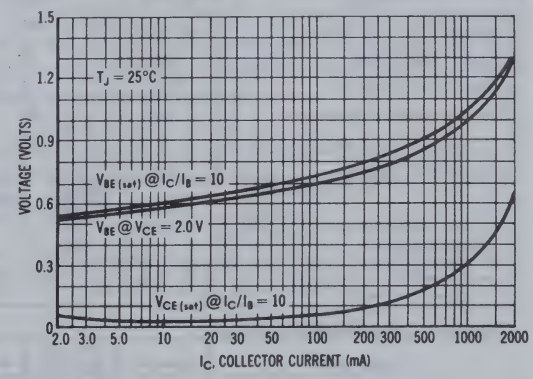
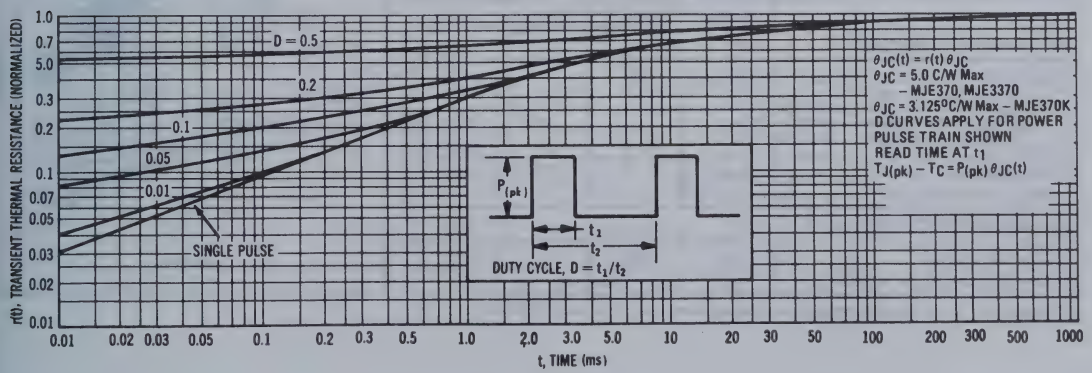


FIGURE 5 – THERMAL RESPONSE



MJE371 (SILICON)
MJE371K
MJE3371

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTORS

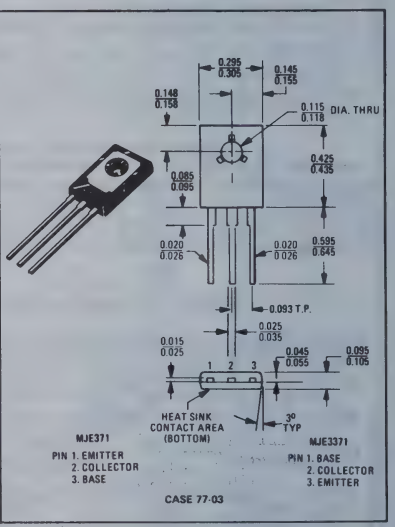
. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 20 Watt audio amplifiers utilizing complementary symmetry circuitry.

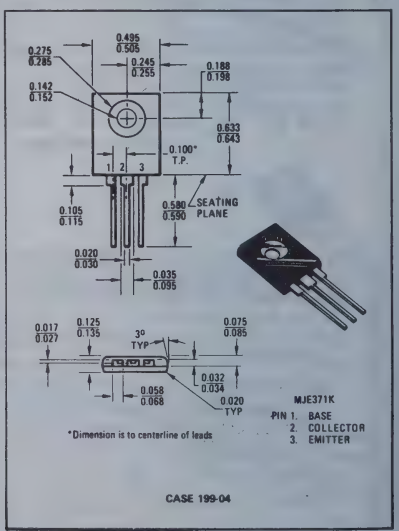
- DC Current Gain – h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE371, MJE371K and MJE3371 are Complementary with NPN MJE521, MJE521K and MJE3521
- Choice of Packages – MJE371, 40 W – Case 77 (E-C-B)
  MJE3371, 40 W – Case 77 R (B-C-E)
  MJE371K, 60 W – Case 199

4 AMPERE POWER TRANSISTORS

PNP SILICON

40 VOLTS
40 and 60 WATTS





MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	4.0		Adc
– Peak		8.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE371 MJE3371	MJE371K	
Total Device Dissipation @ T_C = 25°C	P_D	40	60	Watts
Derate above 25°C		320	480	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE371 MJE3371	MJE371K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs Duty Cycle ≤ 2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE371, MJE3371

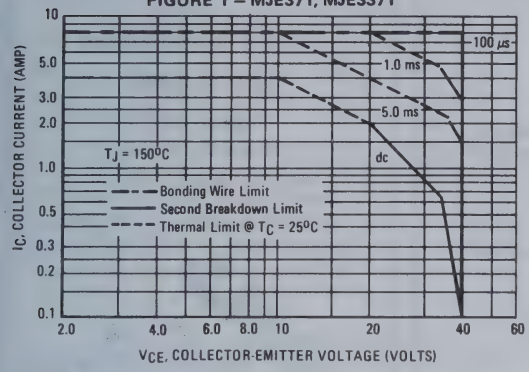
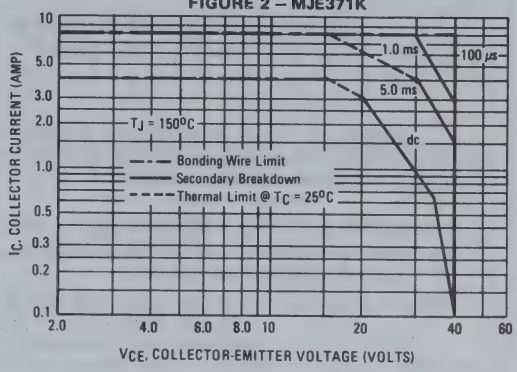


FIGURE 2 – MJE371K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 1 and 2 based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J)pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

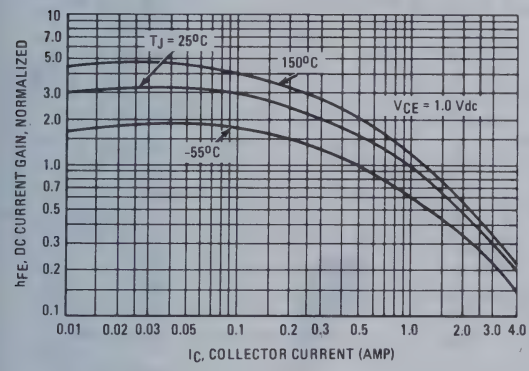


FIGURE 4 – "ON" VOLTAGE

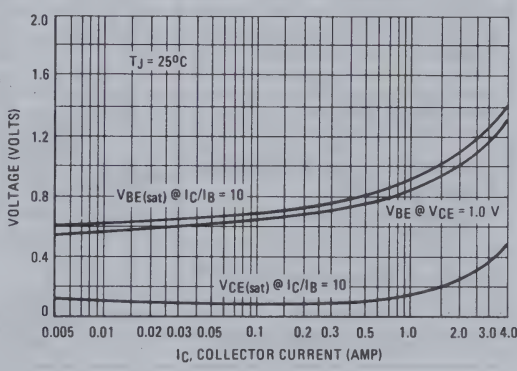
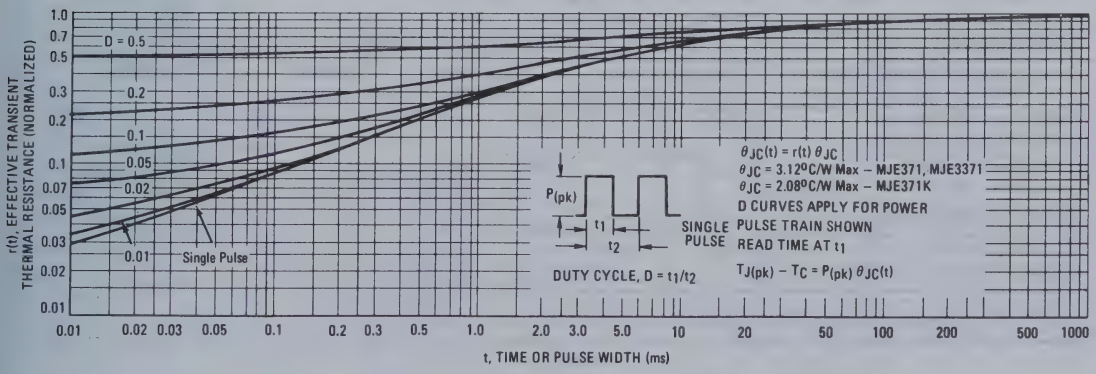


FIGURE 5 – THERMAL RESPONSE



MJE520 (SILICON)
MJE520K
MJE3520

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTORS

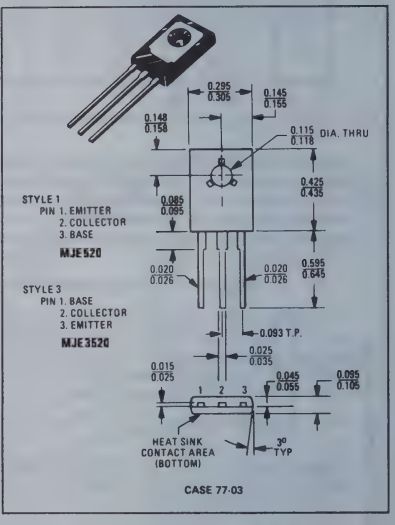
. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain – h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE520, MJE520K and MJE3520 are Complementary with PNP MJE370, MJE370K and MJE3370
- Choice of Packages – MJE520, 25 W – Case 77 (E-C-B)
  MJE3520, 25 W – Case 77 (B-C-E)
  MJE520K, 40 W – Case 199

3 AMPERE POWER TRANSISTORS

NPN SILICON

30 VOLTS
25 and 40 WATTS



CASE 77-03

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
– Peak		7.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE520 MJE3520	MJE520K	
Total Device Dissipation @ T_C = 25°C	P_D	25	40	Watts
Derate above 25°C		0.2	0.32	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150		°C

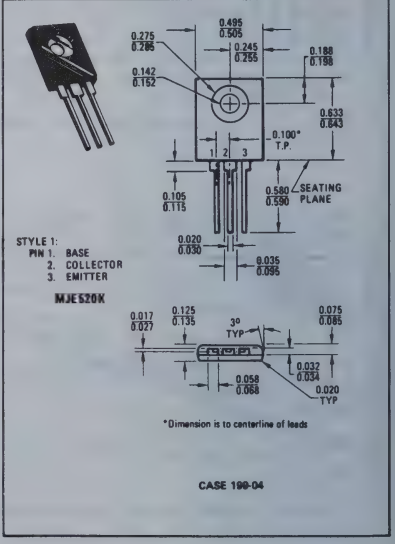
THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE520 MJE3520	MJE520K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	3.125	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



CASE 199-04

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE520, MJE3520

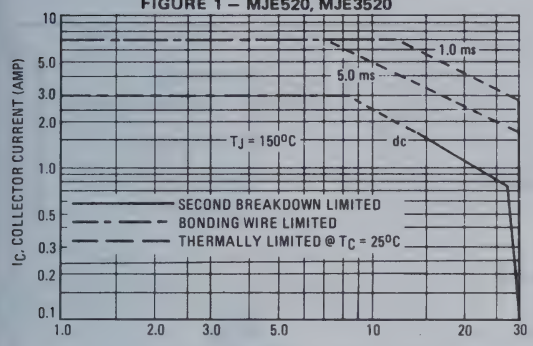
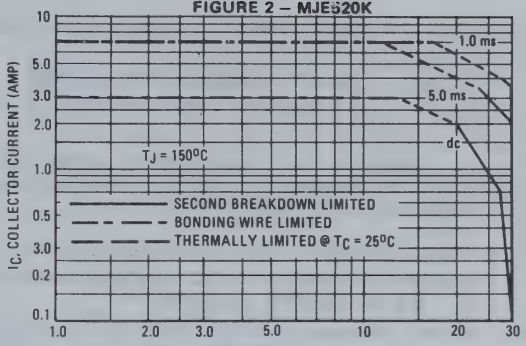


FIGURE 2 – MJE520K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 1 and 2 based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided (T_{Jpk}) ≤ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

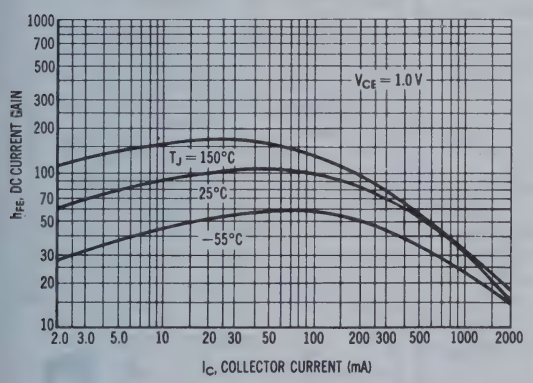


FIGURE 4 – "ON" VOLTAGE

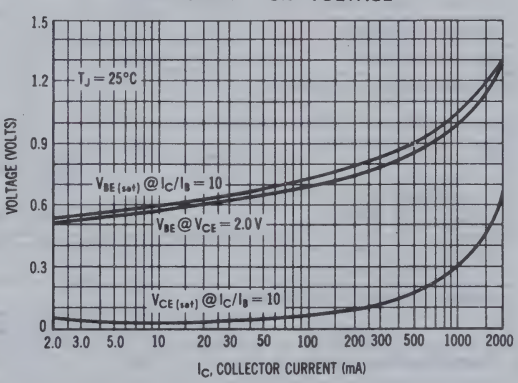
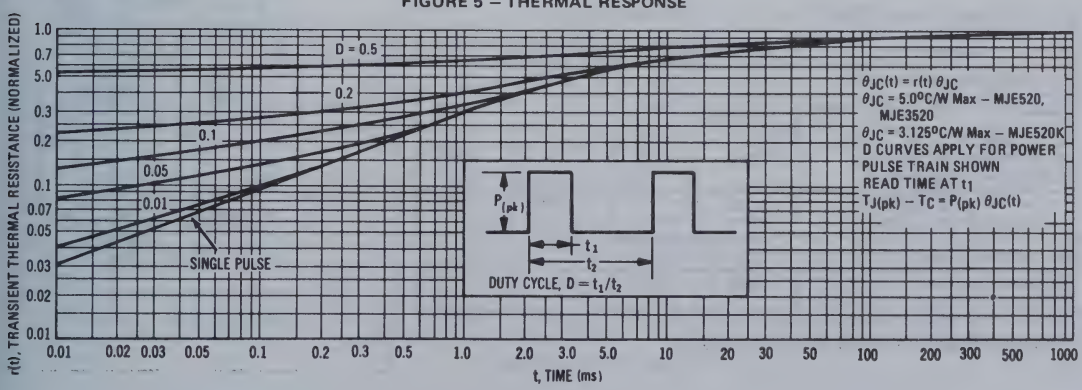


FIGURE 5 – THERMAL RESPONSE



MJE521 (SILICON)
MJE521K
MJE3521

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTORS

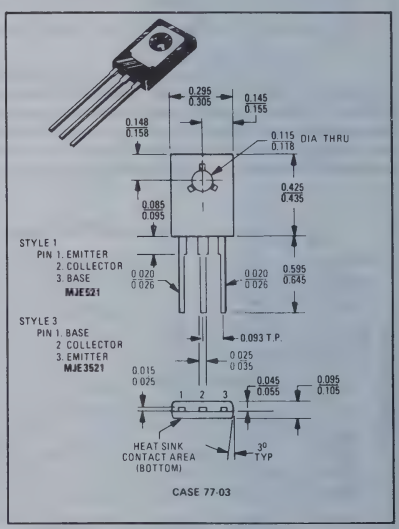
. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 20 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain — h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE521, MJE521K and MJE3521 are Complementary with PNP MJE371, MJE371K and MJE3371
- Choice of Packages — MJE521, 40 W — Case 77 (E-C-B)
  MJE3521, 40 W — Case 77 (B-C-E)
  MJE521K, 60 W — Case 199

4 AMPERE POWER TRANSISTORS

NPN SILICON

40 VOLTS
40 and 60 WATTS



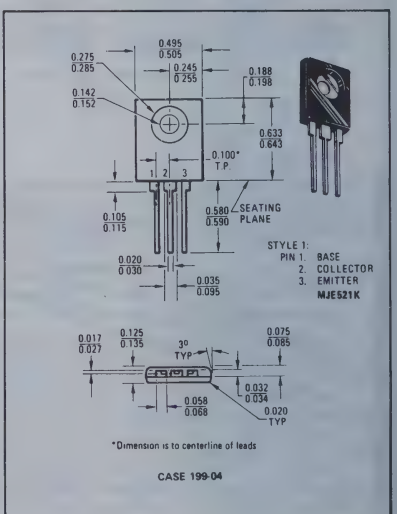
CASE 77-03

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	4.0		Adc
— Peak		8.0		
Base Current — Continuous	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	MJE521 MJE3521: 40	MJE521K: 60	Watts
Derate above 25°C		320	480	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE521 MJE3521	MJE521K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	°C/W



*Dimension is to centerline of leads

CASE 199-04

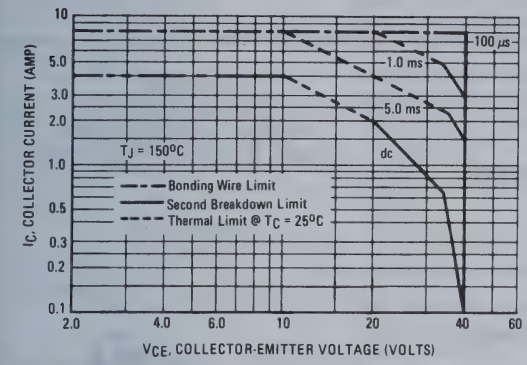
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

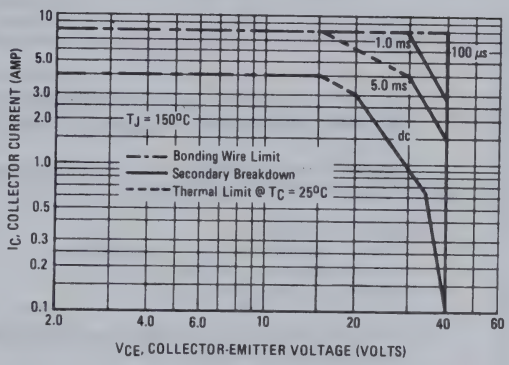
ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE521, MJE3521



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

FIGURE 2 – MJE521K



The data of Figures 1 and 2 based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J)pk)} \leq 150^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

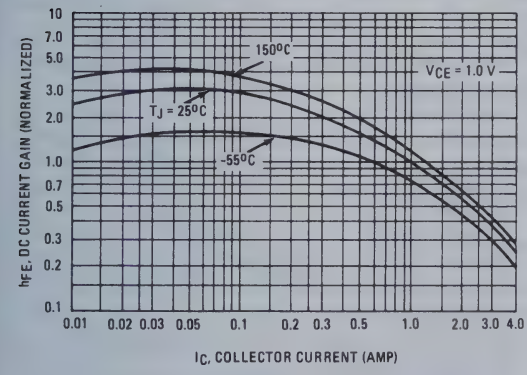


FIGURE 4 – "ON" VOLTAGE

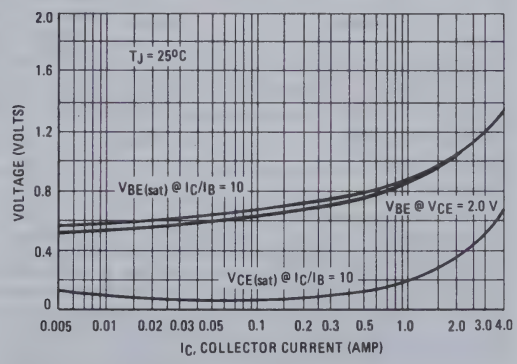
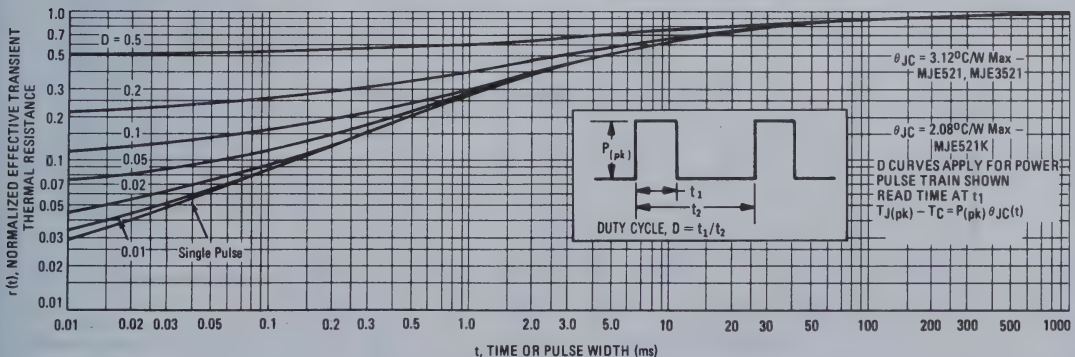


FIGURE 5 – THERMAL RESPONSE



MJE700 thru MJE703 PNP (SILICON)
MJE800 thru MJE803 NPN

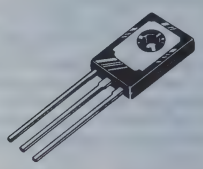
PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . designed to replace discrete driver and output stages in complementary audio amplifier applications.

- High DC Current Gain — h_{FE} = 750 (Min) @ I_C = 1.5 and 2.0 Adc
- Monolithic Construction
- Three Lead Design — Emitter-Base Resistors to Prevent Leakage Multiplication are Built-In.

4.0 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60-80 VOLTS 40 WATTS



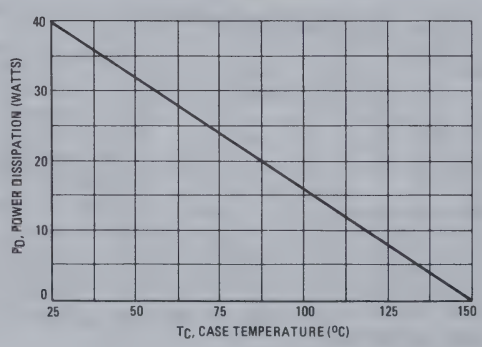
MAXIMUM RATINGS

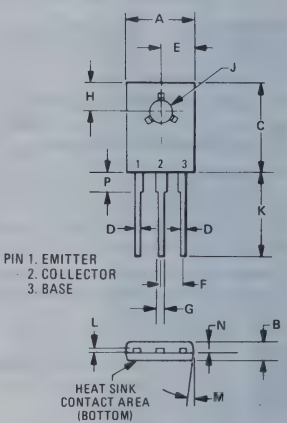
Rating	Symbol	MJE700 MJE701 MJE800 MJE801	MJE702 MJE703 MJE802 MJE803	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	4.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32		Watts W/°C
Operating and Storage Junction Temperating Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.13	°C/W

FIGURE 1 — POWER DERATING





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.295	0.305	7.490	7.750
B	0.095	0.105	2.410	2.670
C	0.425	0.435	10.800	11.050
D	0.020	0.026	0.508	0.660
E	0.145	0.155	3.680	3.940
F	0.093 TP		2.360 TP	
G	0.025	0.035	0.635	0.889
H	0.148	0.158	3.760	4.010
J	0.115	0.118	2.920	3.000
K	0.595	0.645	15.110	16.380
L	0.015	0.025	0.381	0.635
M	3° TYP		3° TYP	
N	0.045	0.055	1.140	1.400
P	0.085	0.095	2.160	2.410

CASE 77-03

When mounting the device, torque not to exceed 8.0 in.-lb.

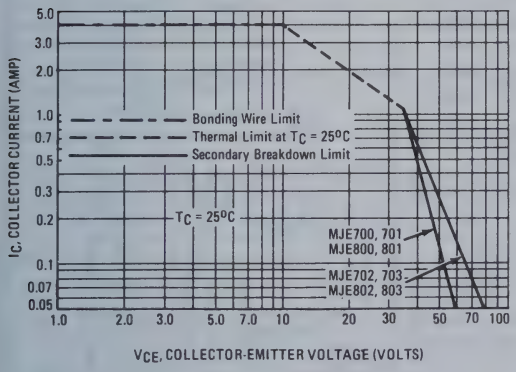
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		BV_{CEO}			Vdc
(I_C = 50 mAdc, I_B = 0)	MJE700, MJE701, MJE800, MJE801		60	–	
	MJE702, MJE703, MJE802, MJE803		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJE700, MJE701, MJE800, MJE801		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE702, MJE703, MJE802, MJE803		–	500	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated BV_{CEO}, I_E = 0)			–	0.2	
(V_{CB} = Rated BV_{CEO}, I_E = 0, T_C = 100°C)			–	2.0	
Emitter Cutoff Current		I_{EBO}	–	2.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 1.5 Adc, V_{CE} = 3.0 Vdc)	MJE700, MJE702, MJE800, MJE802		750	–	
(I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)	MJE701, MJE703, MJE801, MJE803		750	–	
Collector-Emitter Saturation Voltage(1)					
(I_C = 1.5 Adc, I_B = 30 mAdc)	MJE700, MJE702, MJE800, MJE802	$V_{CE(sat)}$	–	2.5	Vdc
(I_C = 2.0 Adc, I_B = 40 mAdc)	MJE701, MJE703, MJE801, MJE803		–	2.8	
Base-Emitter On Voltage(1)		$V_{BE(on)}$			Vdc
(I_C = 1.5 Adc, V_{CE} = 3.0 Vdc)	MJE700, MJE702, MJE800, MJE802		–	2.5	
(I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)	MJE701, MJE703, MJE801, MJE803		–	2.5	
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain		h_{fe}	1.0	–	–
(I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)					

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

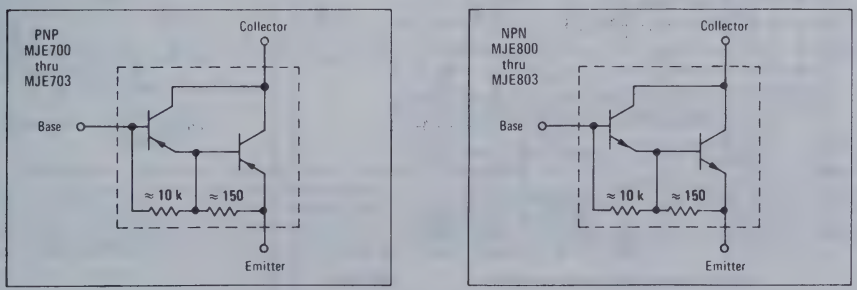
FIGURE 2 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC



MJE710 (SILICON)
MJE711
MJE712

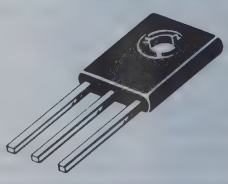
PNP SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in low power amplifiers, as drivers in high-power amplifier and medium-speed switching circuits.

- DC Current Gain —
  h_{FE} = 40 (Min) @ I_C = 150 mAdc
  = 20 (Min) @ I_C = 500 mAdc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40, 60, 80 Vdc (Min) @ I_C = 50 mAdc
- Complement to NPN Types MJE720, MJE721, MJE722 Series
- Equivalent to the Specifications of the Pro-Electron BD166, BD168 and BD170 Transistors

1.5 AMPERE
POWER TRANSISTORS
PNP SILICON

40, 60, 80 VOLTS
20 WATTS



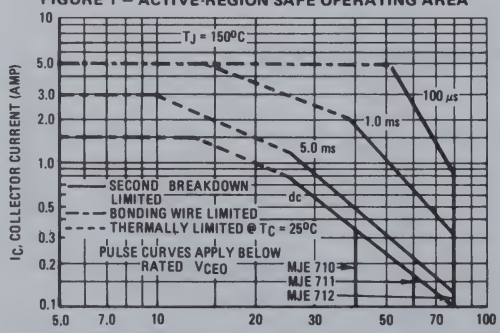
MAXIMUM RATINGS

Rating	Symbol	MJE 710	MJE 711	MJE 712	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	1.5			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ T_A = 25°C	P_D	1.25			Watt
Derate above 25°C		0.008			W/°C
Total Device Dissipation @ T_C = 25°C	P_D	20			Watts
Derate above 25°C		0.16			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

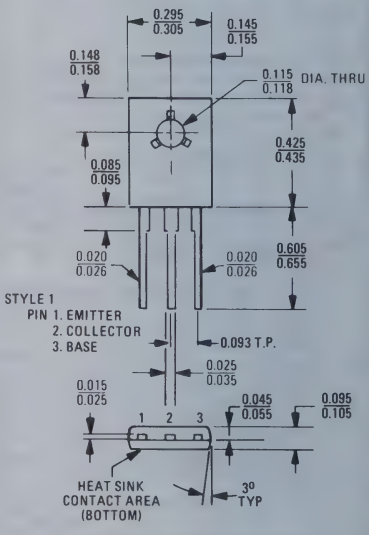
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	100	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



See Note 1



CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	MJE710	$V_{CEO(sus)}$	40	–	Vdc
	MJE711		60	–	
	MJE712		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 20 Vdc, I_B = 0)	MJE710		–	500	
(V_{CE} = 30 Vdc, I_B = 0)	MJE711		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE712		–	500	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE710		–	100	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE711		–	100	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE712		–	100	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE710		–	500	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE711		–	500	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE712		–	500	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			8.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.4	
(I_C = 1.5 Adc, I_B = 300 mAdc			–	1.0	
Base-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 300 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.95	Vdc

FIGURE 2 – DC CURRENT GAIN

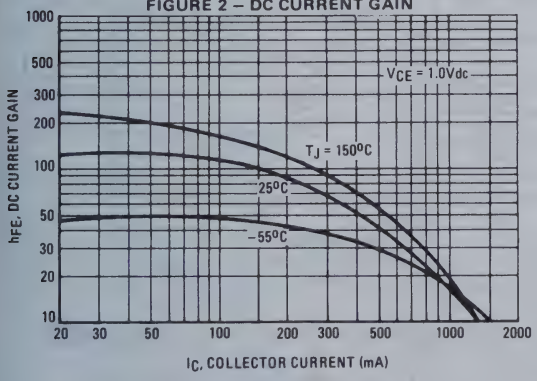
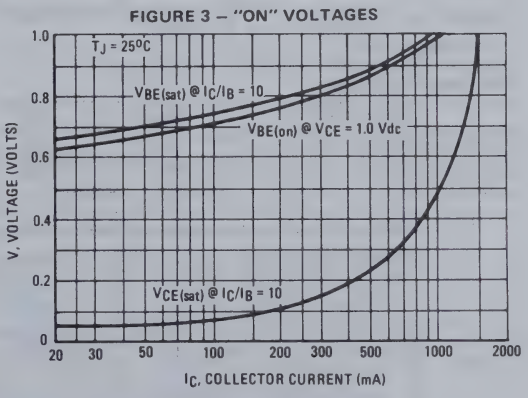


FIGURE 3 – "ON" VOLTAGES



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ ≤150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJE720 (SILICON)
MJE721
MJE722

NPN SILICON MEDIUM-POWER TRANSISTORS

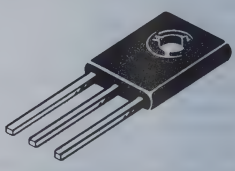
. . . designed for use in low-power amplifiers, as drivers in high-power amplifier and medium-speed switching circuits.

- DC Current Gain –
  h_{FE} = 40 (Min) @ I_C = 150 mAdc
  = 20 (Min) @ I_C = 500 mAdc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40, 60, 80 Vdc (Min) @ I_C = 50 mAdc
- Complement to PNP Types MJE710, MJE711, MJE712 Series
- Equivalent to the Specifications of the Pro-Electron BD165, BD167, and BD169 Transistors

1.5 AMPERE

POWER TRANSISTORS NPN SILICON

40, 60, 80 VOLTS 20 WATTS



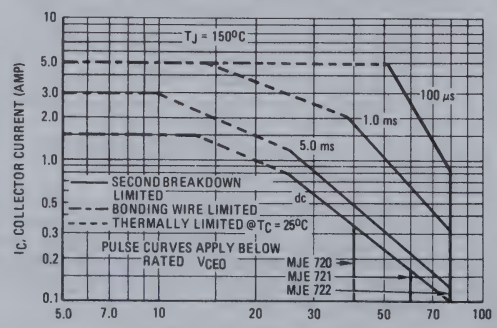
THERMAL CHARACTERISTICS

Rating	Symbol	MJE720	MJE721	MJE722	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current – Continuous	I_C	← 1.5 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ T_A = 25°C	P_D	← 1.25 →			Watt
Derate above 25°C		← 0.008 →			W/°C
Total Device Dissipation @ T_C = 25°C	P_D	← 20 →			Watts
Derate above 25°C		← 0.16 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

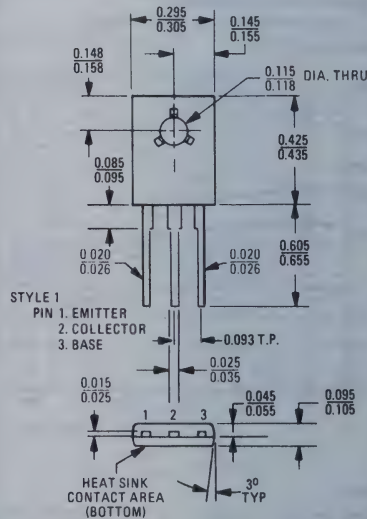
MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	100	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



See Note 1



CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	MJE720	$V_{CEO(sus)}$	40	–	Vdc
	MJE721		60	–	
	MJE722		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 20 Vdc, I_B = 0)	MJE720		–	500	
(V_{CE} = 30 Vdc, I_B = 0)	MJE721		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE722		–	500	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE720		–	100	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE721		–	100	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE722		–	100	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE720		–	500	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE721		–	500	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE722		–	500	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			8.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.4	
(I_C = 1.5 Adc, I_B = 300 mAdc			–	1.0	
Base-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 300 mAdc		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.95	Vdc

FIGURE 2 – DC CURRENT GAIN

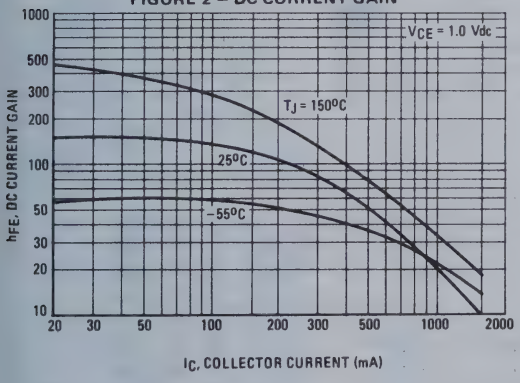
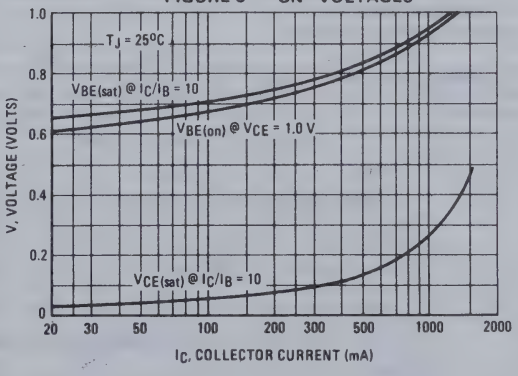


FIGURE 3 – "ON" VOLTAGES



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJE1090 thru MJE1093 PNP (SILICON)
MJE2090 thru MJE2093
MJE1100 thru MJE1103 NPN
MJE2100 thru MJE2103

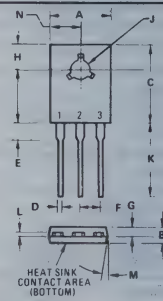
PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

Designed for use in driver and output stages in complementary audio amplifier applications.

- High DC Current Gain – h_{FE} = 750 (Min) @ I_C = 3.0 and 4.0 Adc
- True Three Lead Monolithic Construction – Emitter-Base Resistors to Prevent Leakage Multiplication are Built in.
- Available in Two Packages – Case 90 or Case 199

5.0 AMPERE
DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON
60-80 VOLTS
70 WATTS





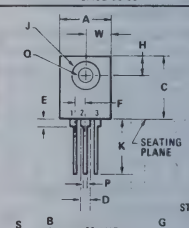
MJE1090
MJE1091
MJE1092
MJE1093
MJE1100
MJE1101
MJE1102
MJE1103

STYLE 2
PIN 1: EMITTER
2. COLLECTOR
3. BASE

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.495	0.505	12.570	12.830
B	0.125	0.135	3.180	3.430
C	0.635	0.645	16.130	16.380
D	0.043	0.049	1.090	1.240
E	0.105	0.115	2.670	2.920
F	0.166 TP		4.220 TP	
G	0.075	0.085	1.910	2.160
H	0.185	0.195	4.700	4.950
J	0.138	0.148	3.510	3.760
K	0.595	0.645	15.110	16.380
L	0.032	0.034	0.813	0.864
M	5° TYP		5° TYP	
N	0.245	0.255	6.220	6.480

NOTE:
DIM. "E" UNCONTROLLED
CASE 90-05





MJE2090
MJE2091
MJE2092
MJE2093
MJE2100
MJE2101
MJE2102
MJE2103

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.495	0.505	12.57	12.33
B	0.125	0.135	3.18	3.43
C	0.633	0.643	16.08	16.33
D	0.035	0.095	2.16	2.41
E	0.105	0.115	2.67	2.92
F	0.100 TP		2.54 TP	
G	0.075	0.085	1.91	2.16
H	0.188	0.198	4.78	5.03
J	0.275	0.285	6.99	7.24
K	0.580	0.590	14.73	14.99
L	0.032	0.034	0.813	0.864
M	3° TYP		3° TYP	
N	0.058	0.068	1.47	1.73
P	0.020	0.030	0.508	0.762
Q	0.142	0.152	3.61	3.86
R	0.020 TYP		0.508 TYP	
S	0.017	0.027	0.432	0.686
W	0.245	0.255	6.22	6.48

NOTE:
1. DIM "F" IS TO CENTERLINE OF LEADS
CASE 199-04

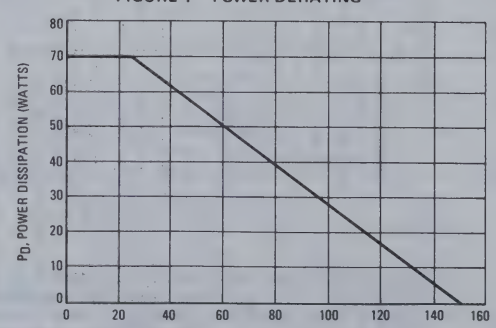
MAXIMUM RATINGS

Rating	Symbol	MJE1090 MJE1091 MJE1100 MJE1101 MJE2090 MJE2091 MJE2100 MJE2101	MJE1092 MJE1093 MJE1102 MJE1103 MJE2092 MJE2093 MJE2102 MJE2103	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	5.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.56		Watts W/°C
Operating and Storage Junction Temperating Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.8	°C/W

FIGURE 1 – POWER DERATING

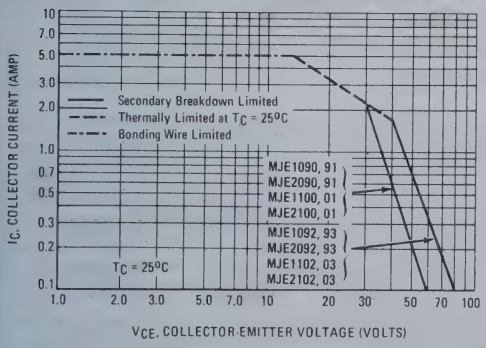


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		BV_{CEO}			Vdc
(I_C = 100 mAdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101		60	–	
	MJE2090, MJE2091, MJE2100, MJE2101		60	–	
	MJE1092, MJE1093, MJE1102, MJE1103		80	–	
	MJE2092, MJE2093, MJE2102, MJE2103		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101		–	500	
	MJE2090, MJE2091, MJE2100, MJE2101		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE1092, MJE1093, MJE1102, MJE1103		–	500	
	MJE2092, MJE2093, MJE2102, MJE2103		–	500	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated BV_{CEO}, I_E = 0)			–	0.2	
(V_{CB} = Rated BV_{CEO}, I_E = 0, T_C = 100°C)			–	2.0	
Emitter Cutoff Current		I_{EBO}	–	2.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		750	–	
	MJE2090, MJE2092, MJE2100, MJE2102		750	–	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		750	–	
	MJE2091, MJE2093, MJE2101, MJE2103		750	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 12 mAdc)	MJE1090, MJE1092, MJE1100, MJE1102		–	2.5	
	MJE2090, MJE2092, MJE2100, MJE2102		–	2.5	
(I_C = 4.0 Adc, I_B = 16 mAdc)	MJE1091, MJE1093, MJE1101, MJE1103		–	2.8	
	MJE2091, MJE2093, MJE2101, MJE2103		–	2.8	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		–	2.5	
	MJE2090, MJE2092, MJE2100, MJE2102		–	2.5	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		–	2.5	
	MJE2091, MJE2093, MJE2101, MJE2103		–	2.5	
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain		h_{fe}	1.0	–	–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)					

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

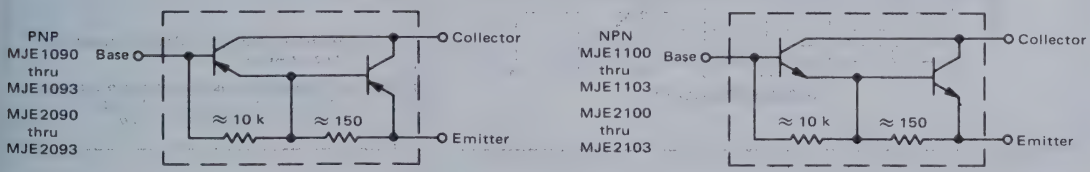
FIGURE 2 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC



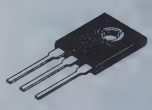
MJE1290, MJE1291 PNP (SILICON)
MJE1660, MJE1661 NPN

COMPLEMENTARY SILICON
MEDIUM-POWER TRANSISTORS

. . . designed for use in power amplifier and switching applications.

- High Collector Current – I_C = 15 Adc
- High DC Current Gain – h_{FE} = 10 (Min) @ I_C = 15 Adc

15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
40-60 VOLTS
90 WATTS



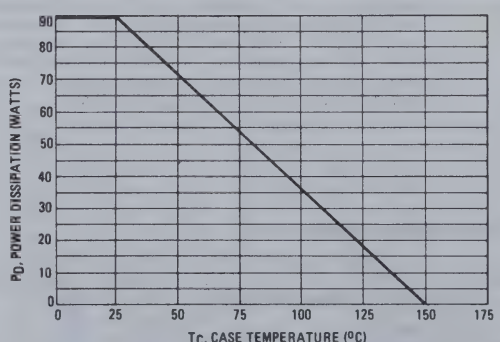
MAXIMUM RATINGS

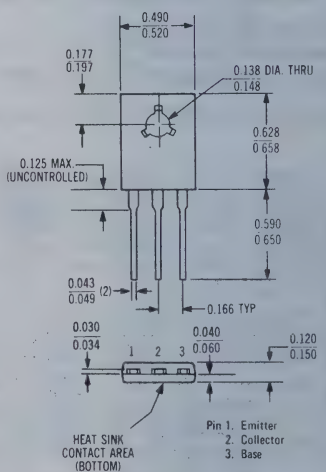
Rating	Symbol	MJE1290 MJE1660	MJE1291 MJE1661	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current-Continuous	I_C	15		Adc
Base Current	I_B	5.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	90 0.72		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





CASE 90 (2)

When mounting the device, torque not to exceed 8.0 in.-lb.

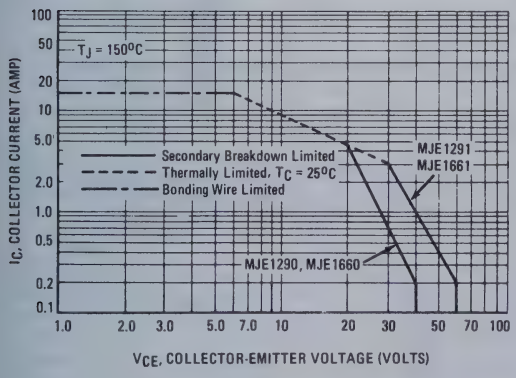
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	MJE1290, MJE1660		40	–	
	MJE1291, MJE1661		60	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)			–	1.0	
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 0)	MJE1290, MJE1660		–	0.7	
(V_{CE} = 60 Vdc, V_{BE} = 0)	MJE1291, MJE1661		–	0.7	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	MJE1290, MJE1660		–	0.7	
(V_{CB} = 60 Vdc, I_E = 0)	MJE1291, MJE1661		–	0.7	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5.0 Vdc, I_E = 0)			–	1.0	
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 5.0 Adc, V_{CE} = 4.0 Vdc)			20	100	
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 15 Adc, I_B = 1.5 Adc)			–	1.8	
Base-Emitter on Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)			–	2.5	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product		f_T			MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)			3.0	–	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	–	

(1) Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2010, MJE2011 PNP (SILICON)
MJE2020, MJE2021 NPN

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 3.5 Adc
- High DC Current Gain –
  h_{FE} = 25-125 @ I_C = 1.0 Adc

5.0 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

40-60 VOLTS
80 WATTS



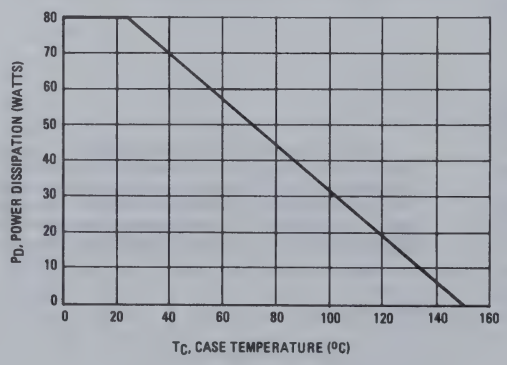
MAXIMUM RATINGS

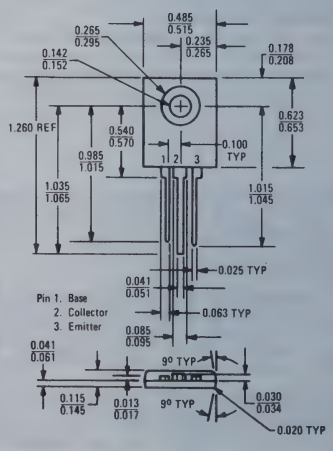
Rating	Symbol	MJE2010 MJE2020	MJE2011 MJE2021	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	5.0		Adc
Base Current	I_B	3.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	80 0.64		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.563	°C

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





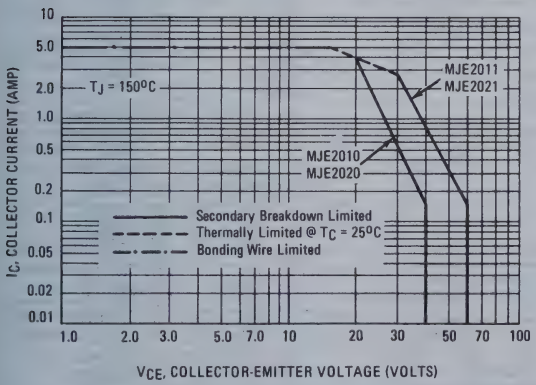
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	MJE2010, MJE2020		40	–	
	MJE2011, MJE2021		60	–	
Collector Cutoff Current		I_{CEO}	–	0.7	mAdc
(V_{CE} = 30 Vdc, I_B = 0)					
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 0)	MJE2010, MJE2020		–	0.4	
(V_{CE} = 60 Vdc, V_{BE} = 0)	MJE2011, MJE2021		–	0.4	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	MJE2010, MJE2020		–	0.4	
(V_{CB} = 60 Vdc, I_E = 0)	MJE2011, MJE2021		–	0.4	
Emitter Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			25	125	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 3.5 Adc, I_B = 350 mAdc)			–	1.0	
(I_C = 5.0 Adc, I_B = 800 mAdc)			–	1.5	
Base-Emitter On Voltage		$V_{BE(on)}$	–	1.6	Vdc
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T	3.0	–	MHz
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)					
Small-Signal Current Gain		h_{fe}	20	–	–
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)					

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicates I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2050 NPN (SILICON)
MJE2150 PNP

SILICON COMPLEMENTARY POWER TRANSISTORS

. . . designed to be used in conjunction with the MC1385P Audio Driver integrated circuit to produce a Class B Audio Amplifier suitable for auto radio.

SILICON
CLASS "B" OUTPUT
TRANSISTORS



MAXIMUM RATINGS

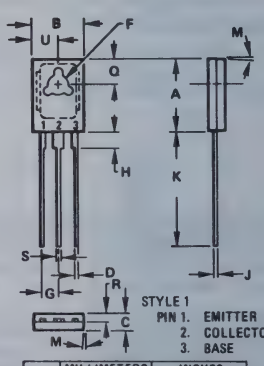
Rating	Symbol	MJE2050	MJE2150	Unit
Collector-Emitter Voltage	V_{CEO}	45	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous Peak	I_C	5.0 10		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	15 0.12		Watts W/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Uni-Base	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage (I_C = 0.2 Adc, R_{BE} = 1.0 k Ohms)	MJE2050 MJE2150	V_{CER}	45 25	– –	Vdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 2.0 Adc, V_{CE} = 1.0 Vdc dc		h_{FE}	50		



STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3^o TYP		3^o TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

MJE2160 (SILICON)

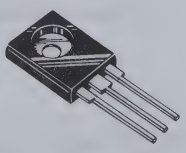
PLASTIC MEDIUM-POWER NPN SILICON TRANSISTOR

. . . designed for line operated audio output amplifier applications in television and radio receivers; as medium power line operated series-pass and switching regulators.

- High Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 300 Vdc (Min) @ I_C = 10 mAdc
- Excellent DC Current Gain — h_{FE} = 30-240 @ I_C = 500 mAdc
- Thermopad Construction: Case 199 — for Metal-to-Metal Mounting

1.5 AMPERE POWER TRANSISTOR NPN SILICON

300 VOLTS
50 WATTS



MAXIMUM RATINGS

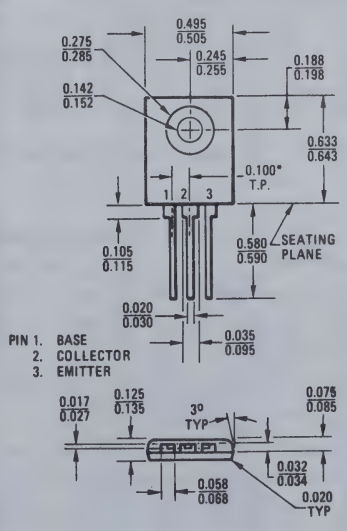
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.4	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc (inductive), L = 50 mH)	$V_{CEO(sus)}$	300	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	–	–	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	–	–	100	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	 30 10	 – –	 240 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	3.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	–	1.2	Vdc
Base-Emitter Voltage Temperature Coefficient (I_C = 50 mAdc, V_{CE} = 10 Vdc) -55°C to +25°C +25°C to +150°C	θ_{VB}	 – –	 1.94 2.14	 – –	 mV/°C mV/°C



*Dimension is to centerline of leads

CASE 199-04

FIGURE 1 – DC CURRENT GAIN

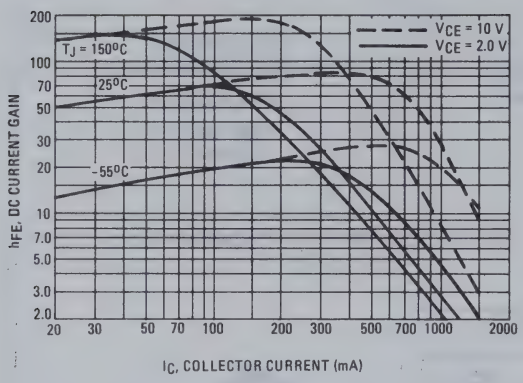


FIGURE 2 – "ON" VOLTAGES

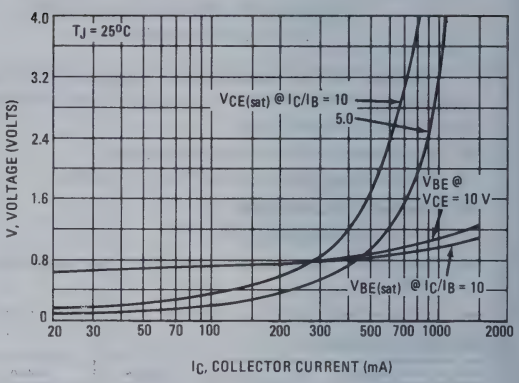
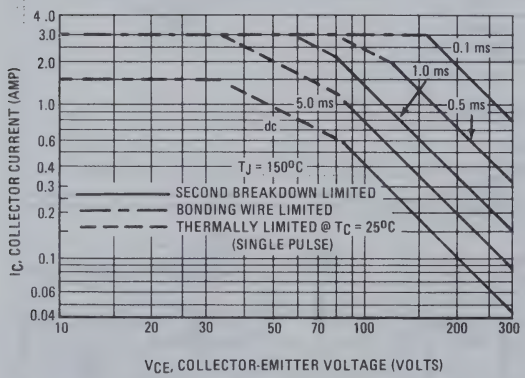


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 4 – POWER DERATING

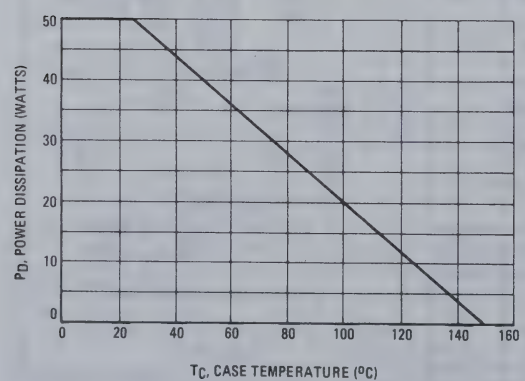
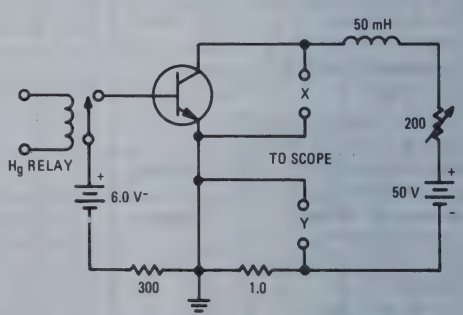


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJE2360 (SILICON)
MJE2361

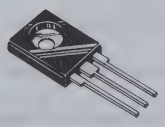
NPN SILICON HIGH-VOLTAGE TRANSISTOR

. . . designed for use in line operated two-watt audio output amplifier applications in televisions and radios.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 350 Vdc (Min) @ I_C = 2.5 mAdc
- Excellent DC Current Gain –
  h_{FE} = 40 (Min) @ I_C = 100 mAdc – MJE2361
- Current-Gain–Bandwidth Product –
  f_T = 10 MHz (Typ) @ I_C = 50 mAdc

0.5 AMPERE
POWER TRANSISTORS
NPN SILICON

350 VOLTS
30 WATTS



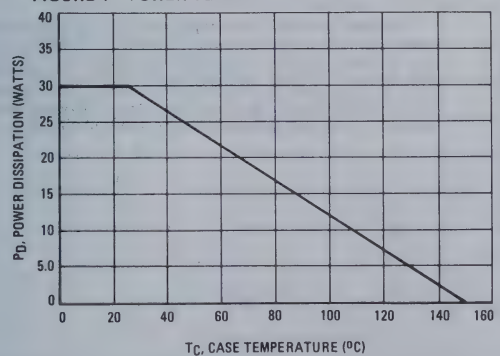
MAXIMUM RATINGS

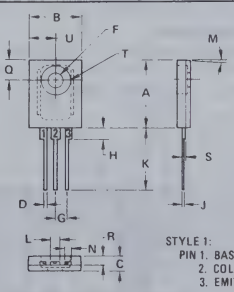
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CB}	375	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	0.5	Adc
Base Current	I_B	0.25	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	30 0.24	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.167	$^oC/W$

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

NOTES:
1. DIM "G" IS TO CENTER OF LEADS

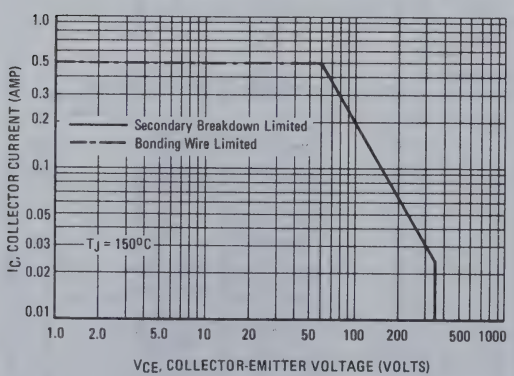
CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (I_C = 2.5 mAdc, I_B = 0)		$V_{CEO(sus)}$	350	–	–	Vdc
Collector Cutoff Current (V_{CE} = 250 Vdc, I_B = 0)		I_{CEO}	–	–	0.25	mAdc
Collector Cutoff Current (V_{CE} = 375 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		I_{CEX}	–	–	0.5	mAdc
Collector Cutoff Current (V_{CB} = 375 Vdc, I_E = 0)		I_{CBO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJE2360		25	–	200	
	MJE2361		50	–	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	MJE2360		15	–	–	
	MJE2361		40	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	–	–	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	–	10	–	MHz
Output Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	–	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2370 (SILICON)
MJE2371

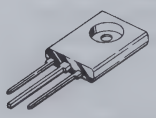
PNP SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifiers as drivers and switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High DC Current Gain –
  h_{FE} = 40-200 @ I_C = 0.2 Adc
- Complements to NPN MJE2520, MJE2521

3.0 AMPERE
POWER TRANSISTORS
PNP SILICON

40-60 VOLTS
40 WATTS



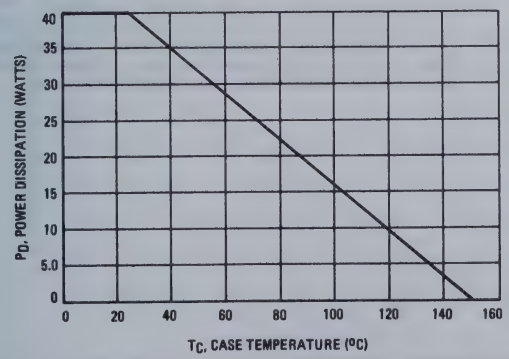
MAXIMUM RATINGS

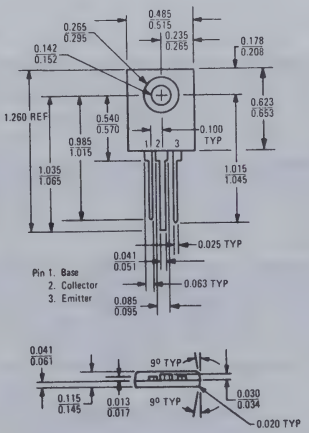
Rating	Symbol	MJE2370	MJE2371	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





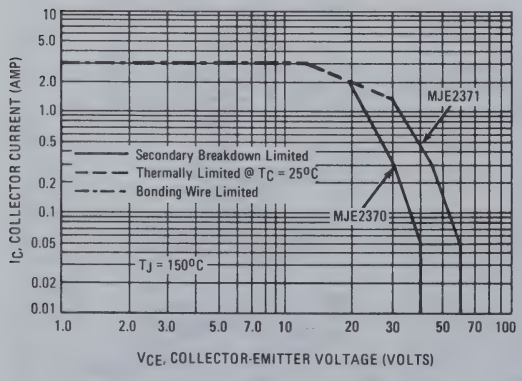
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	MJE2370 MJE2371	$V_{CEO(sus)}$	 40 60	 – –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)		I_{CEO}	–	0.3	mAdc
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 0)	MJE2370		–	0.2	
(V_{CE} = 60 Vdc, V_{BE} = 0)	MJE2371		–	0.2	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 0.2 Adc, V_{CE} = 4.0 Vdc)			40	200	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$	–	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTIC					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2480, MJE2481 (SILICON)
MJE2482, MJE2483

NPN SILICON MEDIUM-POWER TRANSISTORS

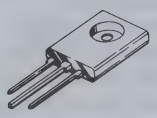
. . . designed for use in general-purpose amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.5 Adc
- DC Current Gain –
  h_{FE} = 20–100 @ I_C = 2.5 Adc
- Current-Gain–Bandwidth Product –
  f_T = 2.0 MHz (Min) @ I_C = 1.0 Adc

4.0 AMPERE

POWER TRANSISTORS NPN SILICON

40–60 VOLTS
60 WATTS



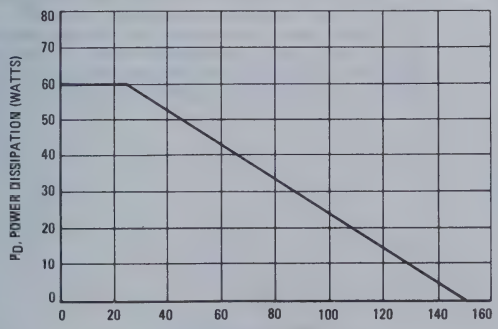
MAXIMUM RATINGS

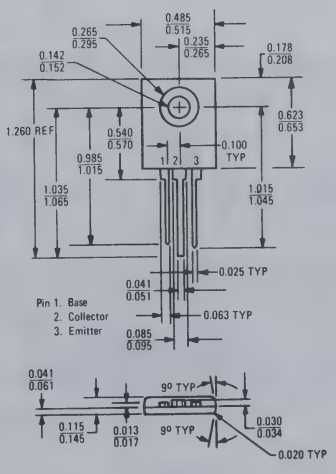
Rating	Symbol	MJE2480 MJE2482	MJE2481 MJE2483	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	4.0		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 0.48		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.083	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





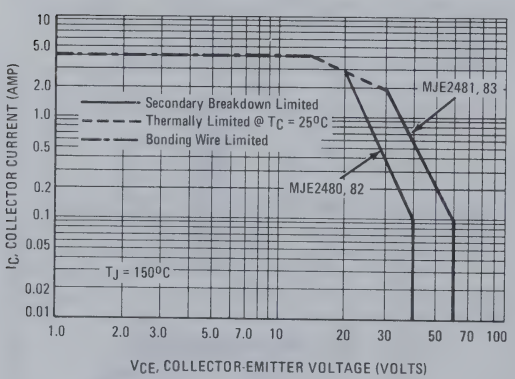
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	MJE2480, MJE2482	$V_{CEO(sus)}$	40	–	Vdc
	MJE2481, MJE2483		60	–	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	MJE2480, MJE2482	I_{CEO}	–	1.0	mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJE2481, MJE2483		–	1.0	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	MJE2480, MJE2482	I_{CBO}	–	0.1	mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJE2481, MJE2483		–	0.1	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	All Types	h_{FE}	40	–	–
(I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)	MJE2480, MJE2481		20	100	
(I_C = 2.5 Adc, V_{CE} = 4.0 Vdc)	MJE2482, MJE2483		20	100	
Collector-Emitter Saturation Voltage(1) (I_C = 1.5 Adc, I_B = 0.15 Adc)		$V_{CE(sat)}$	–	0.7	Vdc
(I_C = 4.0 Adc, I_B = 1.0 Adc)			–	1.4	
Base-Emitter On Voltage (I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

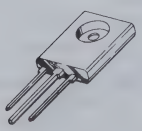
MJE2490 (SILICON)
MJE2491

PNP SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifiers as drivers and as switches.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 3.0 Adc
- High DC Current Gain –
  h_{FE} = 20-100 @ I_C = 1.0 Adc
- Complements to NPN MJE2522 and MJE2523

3.0 AMPERE
POWER TRANSISTORS
PNP SILICON
40–60 VOLTS
60 WATTS



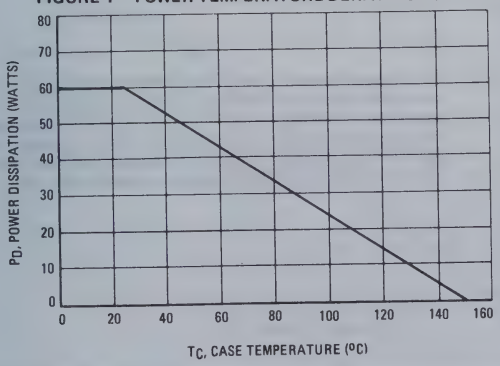
MAXIMUM RATINGS

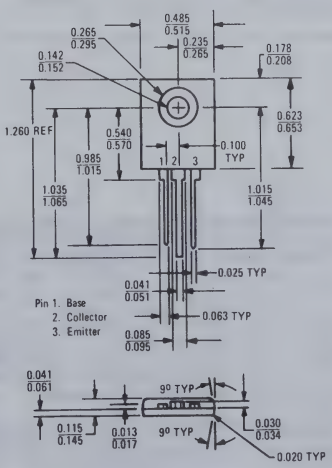
Rating	Symbol	MJE2490	MJE2491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 0.48		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.083	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





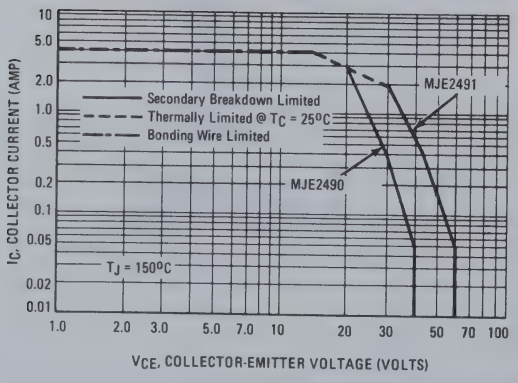
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	MJE2490	$V_{CEO(sus)}$	40	–	Vdc
	MJE2491		60	–	
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)		I_{CEO}	–	0.3	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	MJE2490	I_{CES}	–	0.2	mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)	MJE2491		–	0.2	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		h_{FE}	20	100	–
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)			8.0	–	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	–	0.6	Vdc
(I_C = 3.0 Adc, I_B = 375 mAdc)			–	1.2	
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.3	Vdc
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2520, MJE2521 (SILICON)
MJE2522, MJE2523

NPN SILICON MEDIUM-POWER TRANSISTORS

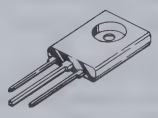
. . . designed for use in general-purpose amplifiers as drivers and as switches.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc (MJE2520, MJE2521)
  0.6 Vdc (Max) @ I_C = 1.0 Adc (MJE2522, MJE2523)
- High DC Current Gain –
  h_{FE} = 20–100 @ I_C = 1.0 Adc (MJE2522, MJE2523)
- Complementary Circuitry –

NPN – MJE2520	PNP – MJE2370
MJE2521	MJE2371
MJE2522	MJE2490
MJE2523	MJE2491

3.0 AMPERE POWER TRANSISTORS NPN SILICON

40–60 VOLTS
40 WATTS



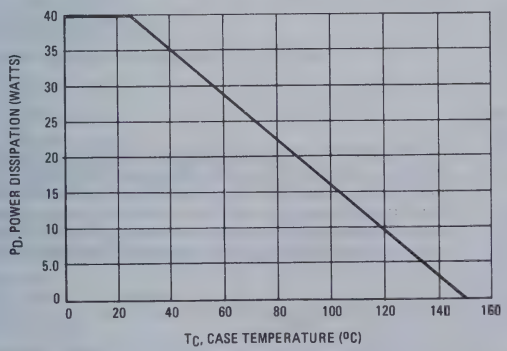
MAXIMUM RATINGS

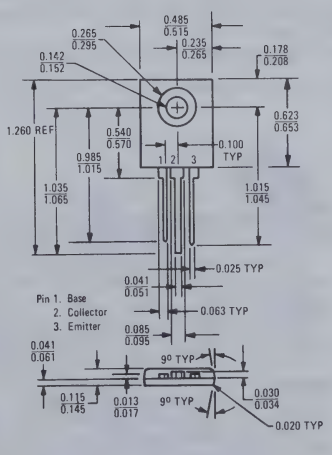
Rating	Symbol	MJE2520 MJE2522	MJE2521 MJE2523	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





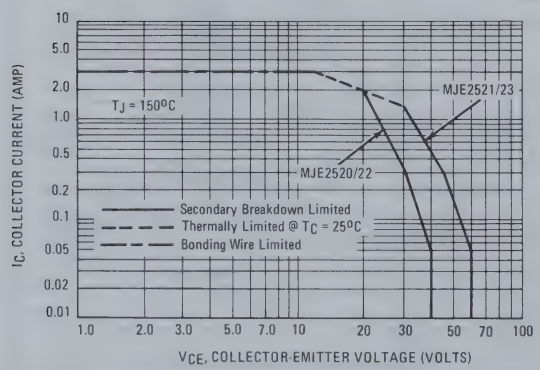
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	MJE2520, MJE2522		40	–	
	MJE2521, MJE2523		60	–	
Collector Cutoff Current		I_{CEO}	–	0.3	mAdc
(V_{CE} = 30 Vdc, I_B = 0)					
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 0)	MJE2520, MJE2522		–	0.2	
(V_{CE} = 60 Vdc, V_{BE} = 0)	MJE2521, MJE2523		–	0.2	
Emitter Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{EB} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 0.2 Adc, V_{CE} = 4.0 Vdc)	MJE2520, MJE2521		40	200	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	MJE2520, MJE2521		10	–	
	MJE2522, MJE2523		20	100	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	MJE2522, MJE2523		8.0	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 125 mAdc)	MJE2520, MJE2521		–	0.7	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MJE2522, MJE2523		–	0.6	
(I_C = 3.0 Adc, I_B = 375 mAdc)	MJE2522, MJE2523		–	1.2	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	All Types		–	1.3	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	MJE2522, MJE2523		–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	3.0	–	MHz
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)					
Small-Signal Current Gain		h_{fe}	20	–	–
(I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)					

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2801 (SILICON)
MJE2801K

HIGH-POWER NPN SILICON TRANSISTOR

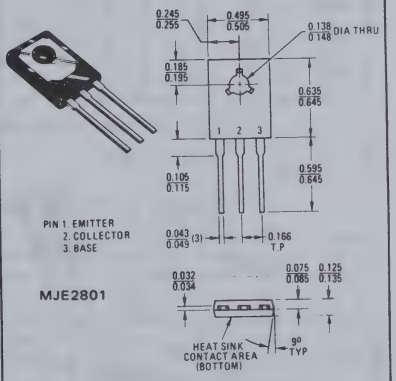
. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE2901, MJE2901K
- Choice of Packages – MJE2801-Case 90
  MJE2801K-Case 199

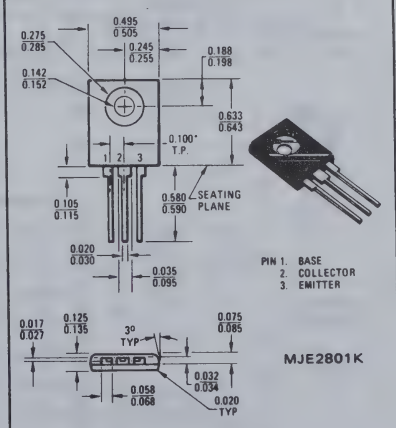
10 AMPERE
POWER TRANSISTORS

NPN SILICON

60 VOLTS
90 WATTS



Case 90-05



Case 199-04

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

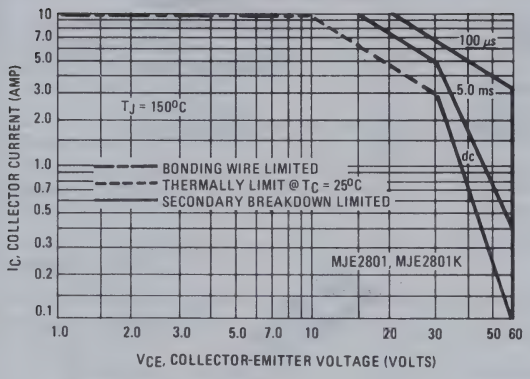
†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	– –	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.4	Vdc

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

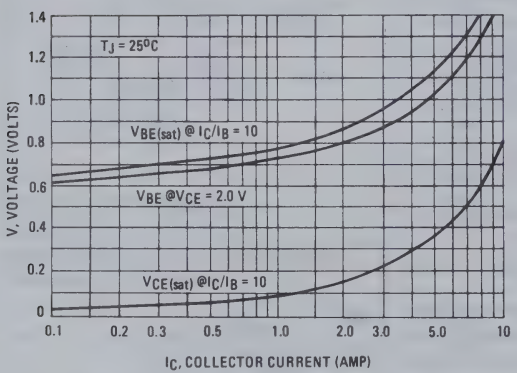


FIGURE 3 – DC CURRENT GAIN

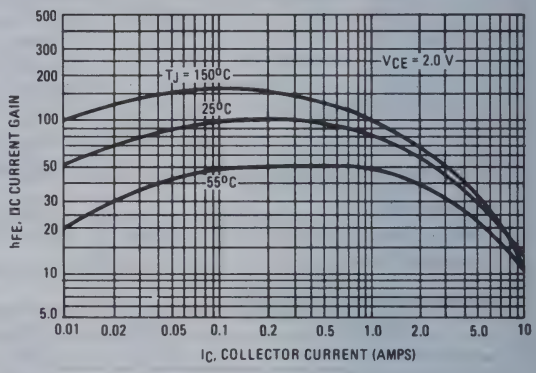
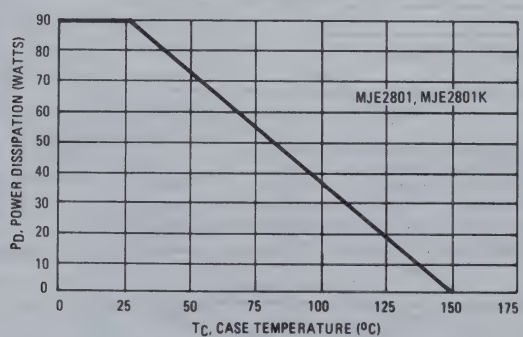


FIGURE 4 – POWER DERATING



MJE2901 (SILICON)
MJE2901K

HIGH-POWER PNP SILICON TRANSISTORS

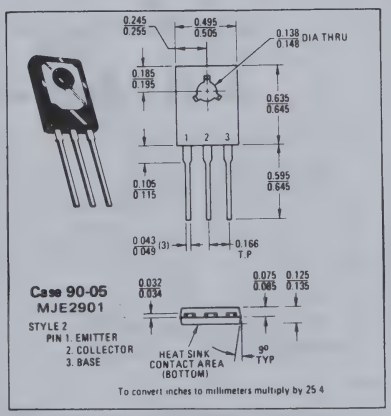
. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad High Efficiency Compact Package
- Complementary to NPN MJE2801, MJE2801K
- Choice of Packages – MJE2901 – Case 90
  MJE2901K – Case 199

10 AMPERE
POWER TRANSISTORS

PNP SILICON

60 VOLTS
90 WATTS



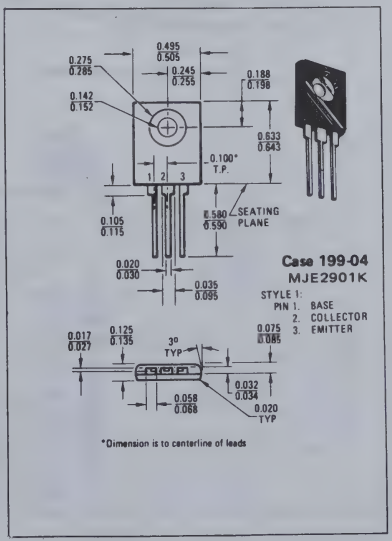
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

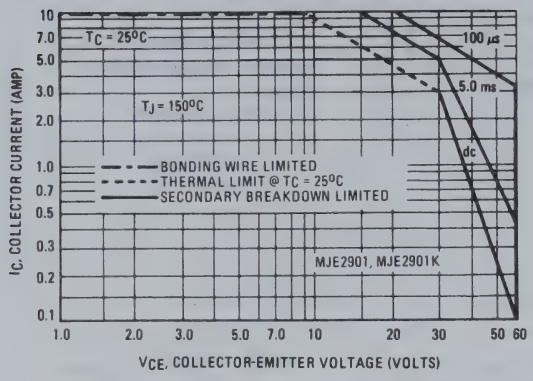


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}(1)	60	–	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C	I_{CBO}	– –	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.4	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

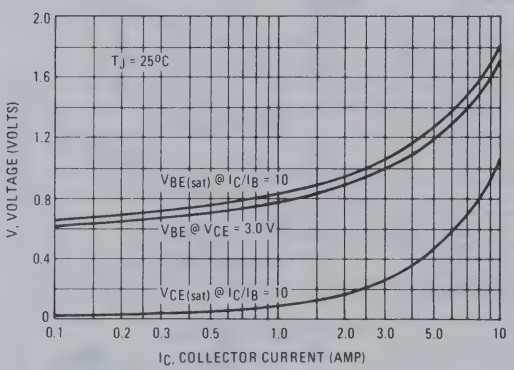


FIGURE 3 – CURRENT GAIN

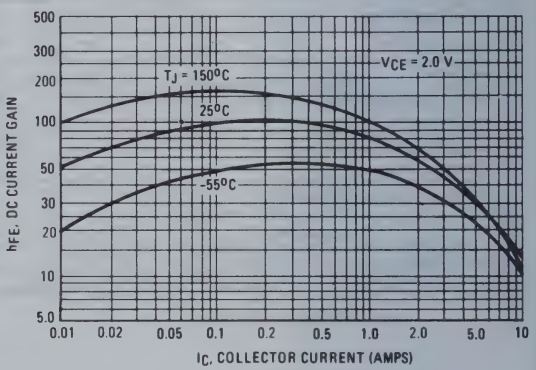
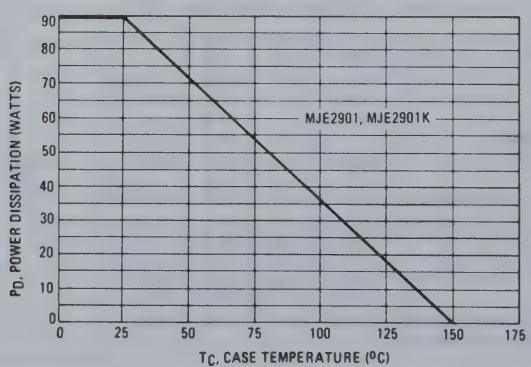


FIGURE 4 – POWER DERATING



MJE2955 (SILICON)
MJE2955K

HIGH POWER PNP SILICON TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current-Gain – Bandwidth Product – f_T = 2.0 MHZ (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Complement to NPN MJE3055, MJE3055K
- Choice of Packages – MJE2955-Case 90, MJE2955K-Case 199

10 AMPERE
POWER TRANSISTORS
PNP SILICON

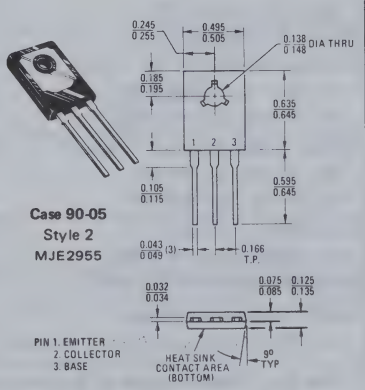
60 VOLTS
90 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	10	Adc
Base Current-Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

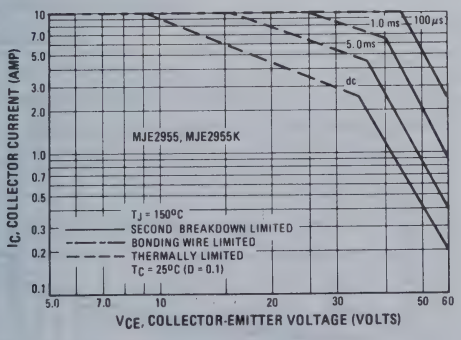
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W



Case 90-05
Style 2
MJE2955

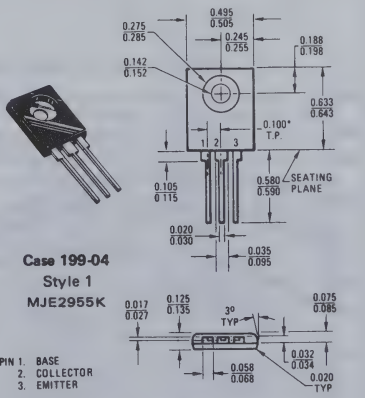
FIGURE 1 – ACTIVE REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ ≤ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

(1) Safe Area Curves are indicated by Figure 1 – Both thermal and safe area limits are applicable and must be observed.



Case 199-04
Style 1
MJE2955K

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	1.0 5.0	mAdc
Collector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0) (V_{CB} = 70 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	– –	1.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	– –	1.1 8.0	Vdc
Base-Emitter On Voltage (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

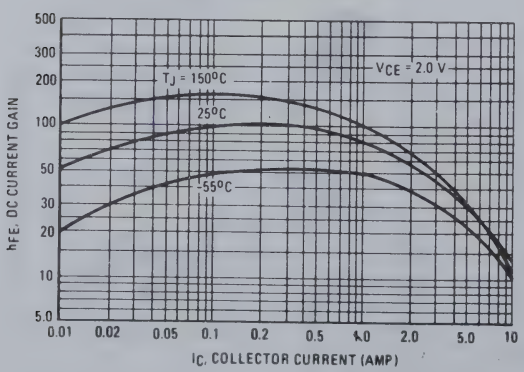
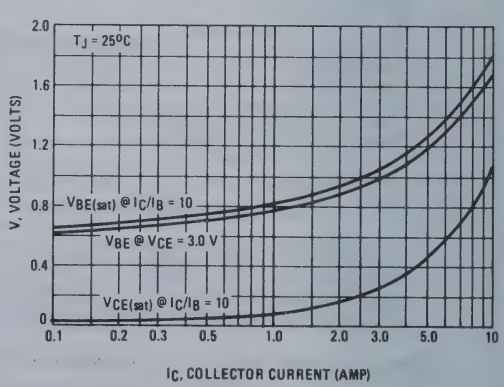


FIGURE 3 – "ON" VOLTAGES



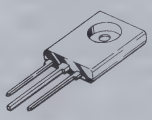
MJE3054 (SILICON)

NPN SILICON MEDIUM-POWER TRANSISTOR

. . . designed for use as drivers, switches and general-purpose amplifiers.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc @ I_C = 0.5 Adc
- High DC Current Gain —
  h_{FE} = 25–100 @ I_C = 0.5 Adc

4.0 AMPERE
POWER TRANSISTORS
NPN SILICON
55 VOLTS
40 WATTS



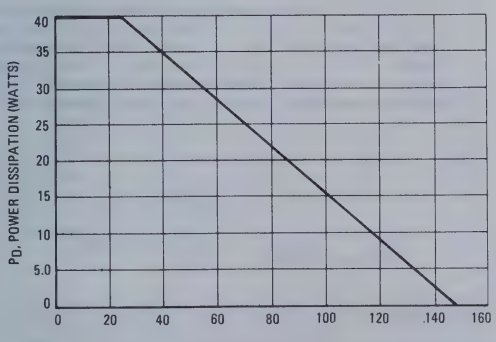
MAXIMUM RATINGS

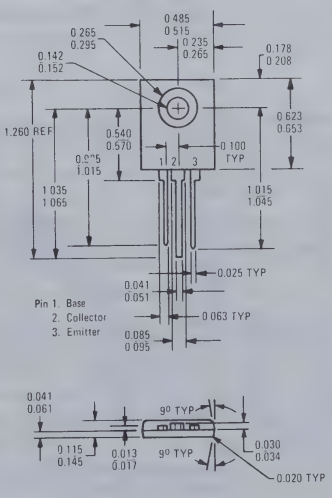
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Emitter Voltage	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





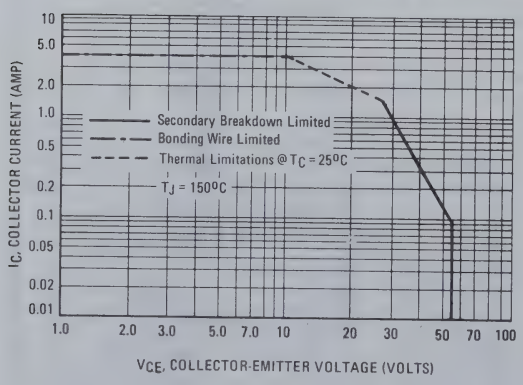
CASE 199

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	55	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, R_{BE} = 100 ohms)	$V_{CER(sus)}$	60	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.5	Adc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 0.5 Adc, V_{CE} = 4.0 Vdc)		25	100	
(I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)		5.0	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 0.5 Adc, I_B = 50 mAdc)		–	1.0	
(I_C = 3.0 Adc, I_B = 1.0 Adc)		–	6.0	
Base-Emitter On Voltage (I_C = 0.5 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.7	Vdc
DYNAMIC CHARACTERISTICS				
Common-Emitter Cutoff Frequency (I_C = 100 mAdc, V_{CE} = 4.0 Vdc)	$f_{\alpha e}$	30	–	kHz
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	25	–	–

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE3055 (SILICON)
MJE3055K

HIGH POWER NPN SILICON TRANSISTORS

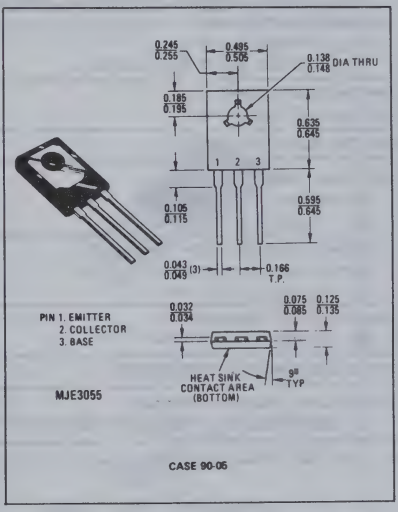
. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current Gain – Bandwidth Product – f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Complement to PNP MJE2955, MJE2955K
- Choice of Packages – MJE3055 – Case 90
  MJE3055K – Case 199

10 AMPERE POWER TRANSISTORS

NPN SILICON

60 VOLTS
90 WATTS



CASE 90-05

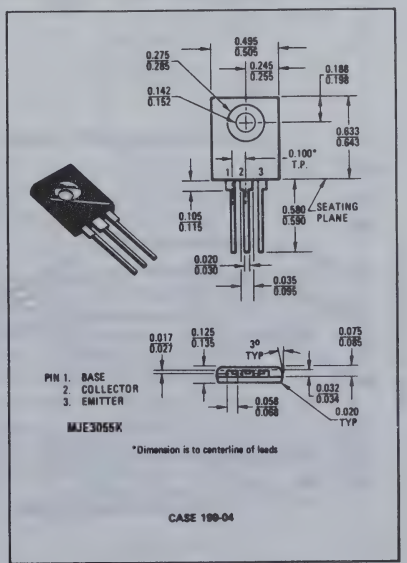
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	10	Adc
Base Current – Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

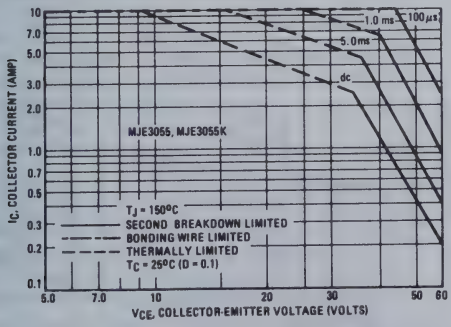
(1) Safe Area Curves are indicated by Figure 1 – Both thermal and safe area limits are applicable and must be observed.



*Dimension is to centerline of leads

CASE 199-04

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ ≤ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	 – –	 1.0 5.0	mAdc
Colltector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0) (V_{CB} = 70 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	 – –	 1.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	 20 5.0	 70 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	 – –	 1.1 8.0	Vdc
Base-Emitter On Voltage (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%.

FIGURE 2 – DC CURRENT GAIN

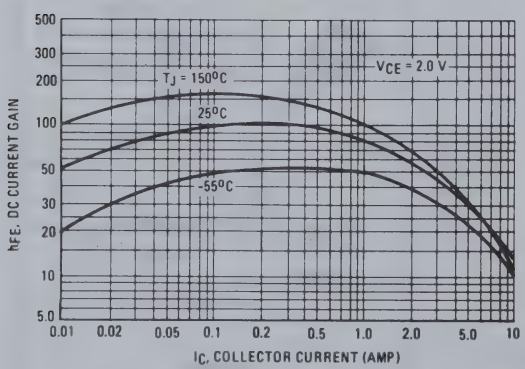
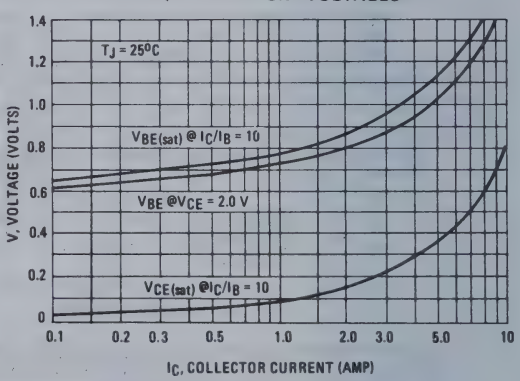


FIGURE 3 – "ON" VOLTAGES



MJE3439, MJE3440 (SILICON)

NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

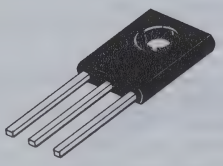
. . . designed for use as video output amplifiers in television receivers and in line operated audio output amplifiers.

- High DC Current Gain – h_{FE} = 40–160 @ I_C = 20 mAdc
- Current-Gain–Bandwidth Product – f_T = 15 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance – C_{ob} = 10 pF (Max) @ f = 1.0 MHz

0.3 AMPERE

NPN SILICON POWER TRANSISTORS

250–350 VOLTS
15 WATTS



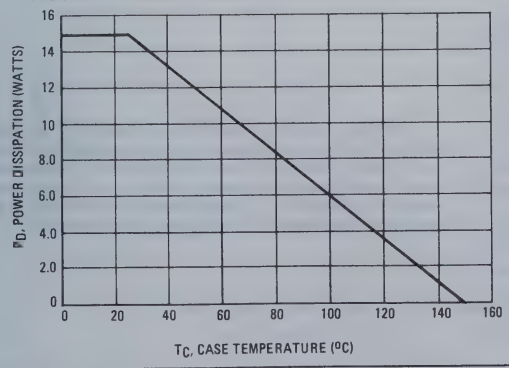
MAXIMUM RATINGS

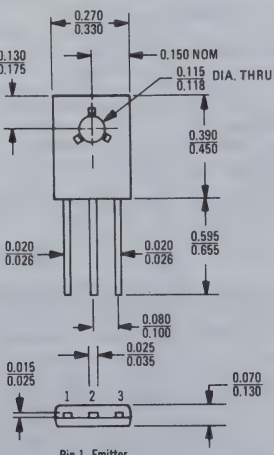
Rating	Symbol	MJE3439	MJE3440	Unit
Collector-Emitter Voltage	V_{CEO}	350	250	Vdc
Collector-Base Voltage	V_{CB}	450	350	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	0.3		Adc
Base Current	I_B	150		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	15 0.12		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.33	$^oC/W$

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb.

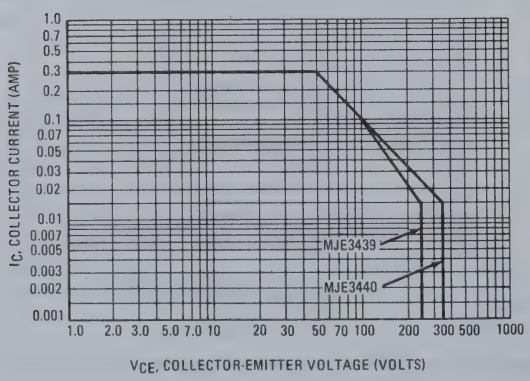
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 5.0 mAdc, I_B = 0)	MJE3439		350	–	
(I_C = 50 mAdc, I_B = 0)	MJE3440		250	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	MJE3439		–	20	
(V_{CE} = 200 Vdc, I_B = 0)	MJE3440		–	50	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3439		–	500	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3440		–	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 360 Vdc, I_E = 0)	MJE3439		–	20	
(V_{CB} = 250 Vdc, I_E = 0)	MJE3440		–	20	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	20	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			30	–	
(I_C = 20 mAdc, V_{CE} = 10 Vdc)			40	160	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	10	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

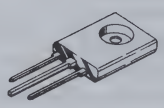
MJE3738 (SILICON)
MJE3739

NPN SILICON HIGH-VOLTAGE TRANSISTORS

. . . designed for use in line-operated equipment such as audio output amplifiers, low-current, high-voltage converters, and AC line relay applications.

- DC Current Gain –
  h_{FE} = 40–200 @ I_C = 100 mAdc
- Current-Gain–Bandwidth Product –
  f_T = 10 MHz (Typ) @ I_C = 50 mAdc

0.5 AMPERE
POWER TRANSISTORS
NPN SILICON
225–300 VOLTS
30 WATTS



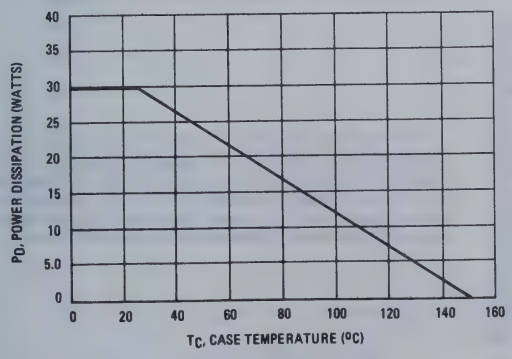
MAXIMUM RATINGS

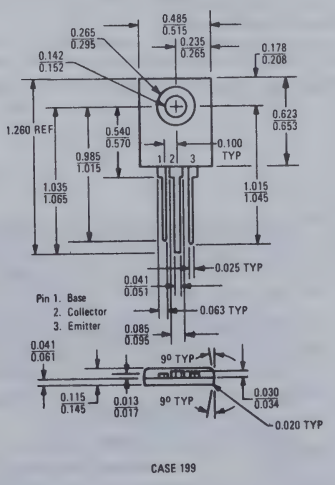
Rating	Symbol	MJE3738	MJE3739	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →		Vdc
Collector Current – Continuous	I_C	← 0.5 →		Adc
Base Current	I_B	← 0.5 →		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 30 0.24 →		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.167	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



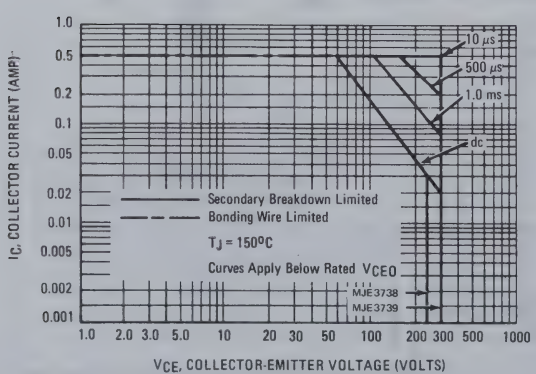


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$				Vdc
(I_C = 30 mAdc, I_B = 0)	MJE3738		225	–	–	
(I_C = 20 mAdc, I_B = 0)	MJE3739		300	–	–	
Collector Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 125 Vdc, I_B = 0)	MJE3738		–	–	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	MJE3739		–	–	0.25	
Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3738		–	–	0.5	
(V_{CE} = 325 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3739		–	–	0.5	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 250 Vdc, I_E = 0)	MJE3738		–	–	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	MJE3739		–	–	0.1	
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	–	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			40	–	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			25	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	–	–	2.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	–	10	–	MHz
Output Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	–	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE3740 (SILICON)
MJE3741

PNP SILICON MEDIUM-POWER TRANSISTORS

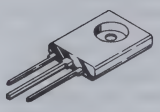
. . . designed for use as drivers, switches, and replacement for germanium and silicon metal can transistors.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 1.0 Adc
- High DC Current Gain –
  h_{FE} = 30–100 @ I_C = 250 mAdc

4.0 AMPERE

POWER TRANSISTORS
PNP SILICON

40–60 VOLTS
40 WATTS



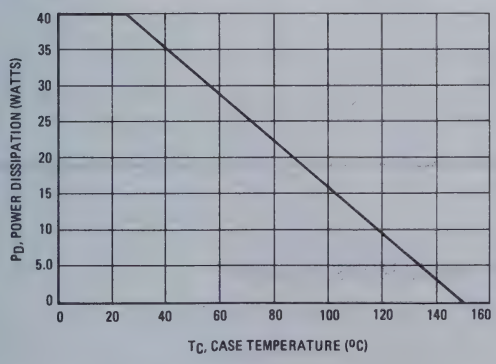
MAXIMUM RATINGS

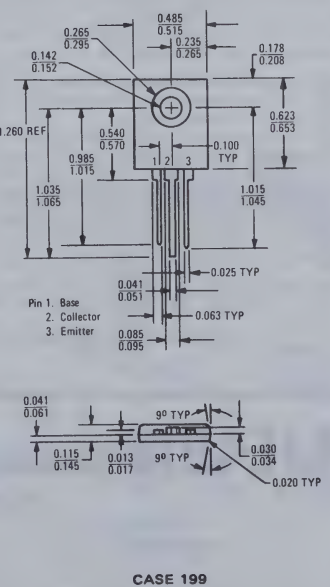
Rating	Symbol	MJE3740	MJE3741	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	4.0		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 199

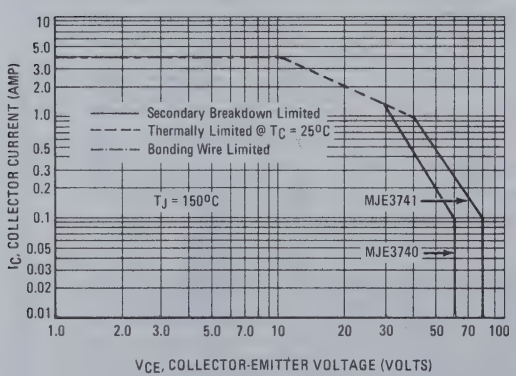
MJE3740, MJE3741 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	MJE3740		60	–	
	MJE3741		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	MJE3740		–	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	MJE3741		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE3740		–	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE3741		–	0.1	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJE3740		–	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	MJE3741		–	0.1	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			30	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	100	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE4918 (SILICON)

For Specifications, See 2N4918, Volume I.

MJE4921 thru MJE4923 (SILICON)

2N4921 thru 2N4923

MEDIUM-POWER PLASTIC NPN SILICON TRANSISTORS

. . . designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage — $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 1.0 Amp
- Excellent Power Dissipation Due to Thermopad Construction — P_D = 30 and 40 W @ T_C = 25°C
- Excellent Safe Operating Area
- Gain Specified to I_C = 1.0 Amp
- Complement to PNP 2N4918, 2N4919, 2N4920 and MJE4918, MJE4919, MJE4920
- Choice of Packages — 2N4921 thru 2N4923, 30 Watts — Case 77
  MJE4921 thru MJE4923, 40 Watts — Case 199

3 AMPERE GENERAL PURPOSE POWER TRANSISTORS

40-80 VOLTS
30 and 40 WATTS

***MAXIMUM RATINGS**

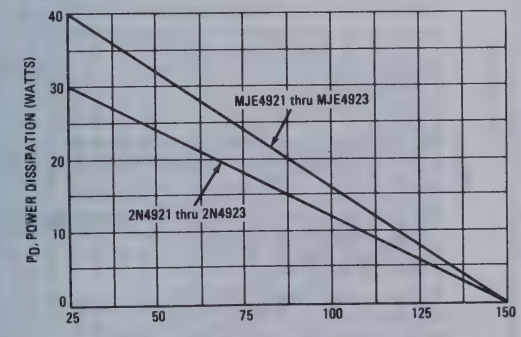
Rating	Symbol	2N4921 MJE4921	2N4922 MJE4922	2N4923 MJE4923	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous (1)	I_C	← 1.0 →			Adc
		← 3.0 →			
Base Current — Continuous	I_B	← 1.0 →			Adc
		2N4921 Series		MJE4921 Series	
Total Device Dissipation @ T_C = 25°C	P_D	30		40	Watts
Derate above 25°C		0.24		0.32	W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +150 →			°C

THERMAL CHARACTERISTICS (2)

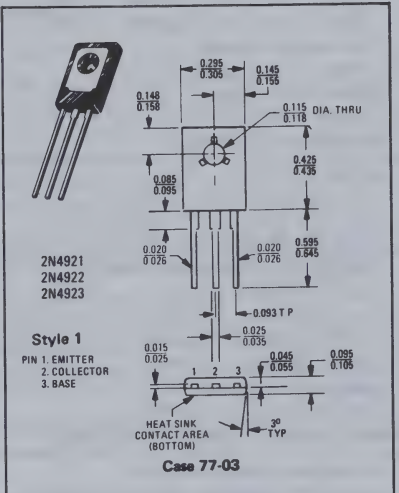
Characteristic	Symbol	2N4921/4923	MJE4921/4923	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	3.125	°C/W

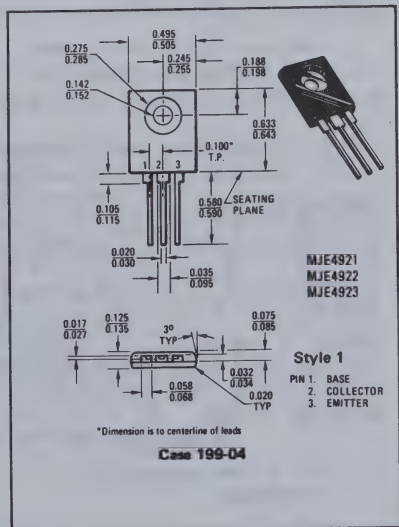
(1) The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figures 5 and 6).
(2) Recommend use of thermal compound for lowest thermal resistance.
*Indicates JEDEC Registered Data for 2N4921 Series.

FIGURE 1 — POWER DERATING



Safe Area Curves are indicated by Figures 5 and 6. All limits are applicable and must be observed





***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)		–	$V_{CEO(sus)}$			Vdc
(I_C = 0.1 Adc, I_B = 0)	2N4921, MJE4921			40	–	
	2N4922, MJE4922			60	–	
	2N4923, MJE4923			80	–	
Collector Cutoff Current		–	I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N4921, MJE4921			–	0.5	
(V_{CE} = 30 Vdc, I_B = 0)	2N4922, MJE4922			–	0.5	
(V_{CE} = 40 Vdc, I_B = 0)	2N4923, MJE4923			–	0.5	
Collector Cutoff Current		13	I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)				–	0.1	
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)				–	0.5	
Collector Cutoff Current		–	I_{CBO}			mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)				–	0.1	
Emitter Cutoff Current		–	I_{EBO}			mAdc
(V_{EB} = 5.0 Vdc, I_C = 0)				–	1.0	
ON CHARACTERISTICS						
DC Current Gain (1)		9	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)				40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)				20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)				10	–	
Collector-Emitter Saturation Voltage (1)		10	$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)		12 14		–	0.6	
Base-Emitter Saturation Voltage (1)		12	$V_{BE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)		14		–	1.3	
Base-Emitter On Voltage (1)		12	$V_{BE(on)}$			Vdc
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		14		–	1.3	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product		–	f_T			MHz
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)				3.0	–	
Output Capacitance		–	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)				–	100	
Small-Signal Current Gain		–	h_{fe}			–
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)				25	–	

(1) Pulse Test: PW≈300 μs, Duty Cycle≈2.0%.

*Indicates JEDEC Registered Data for 2N4921 Series.

FIGURE 2 – SWITCHING TIME EQUIVALENT CIRCUIT

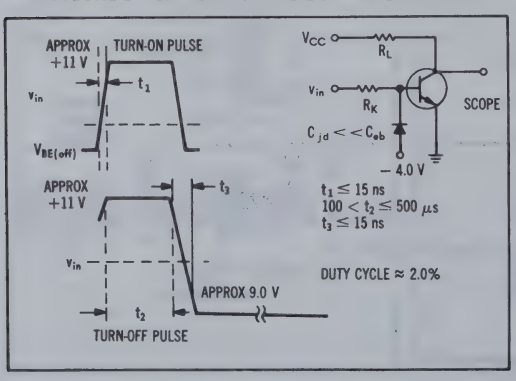


FIGURE 3 – TURN-ON TIME

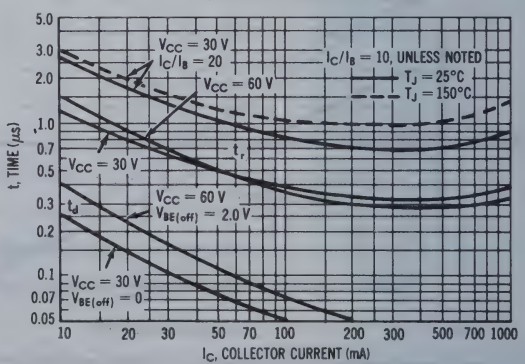
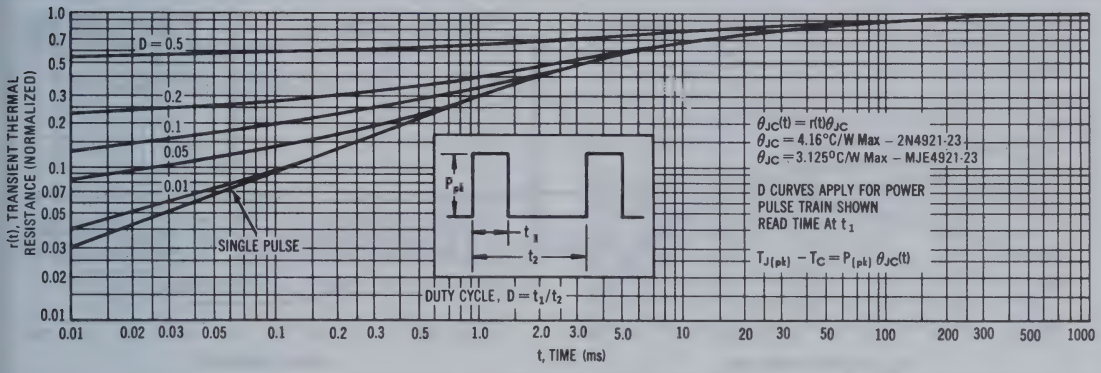


FIGURE 4 – THERMAL RESPONSE



ACTIVE – REGION SAFE OPERATING AREA

FIGURE 5 – 2N4921 thru 2N4923

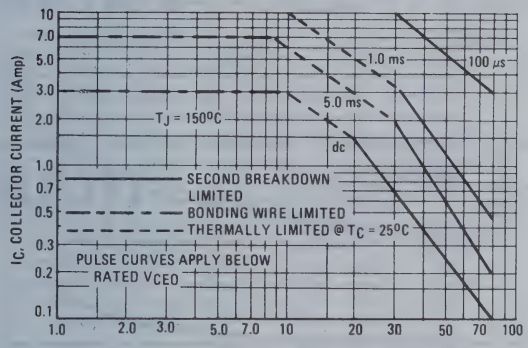
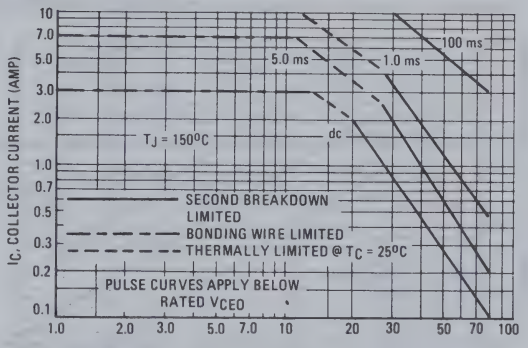


FIGURE 6 – MJE4921 thru MJE4923



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – STORAGE TIME

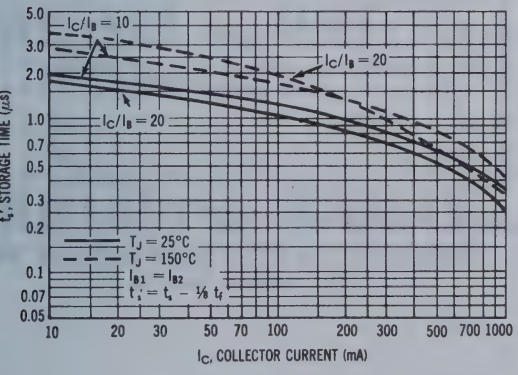


FIGURE 8 – FALL TIME

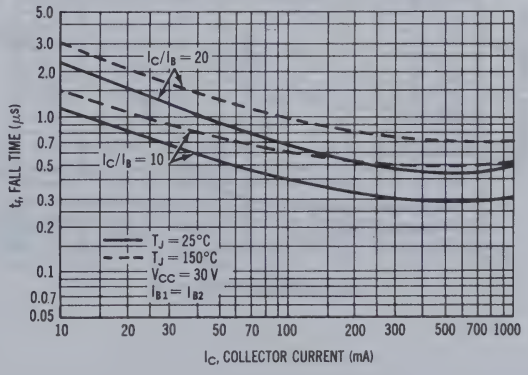


FIGURE 9 – CURRENT GAIN

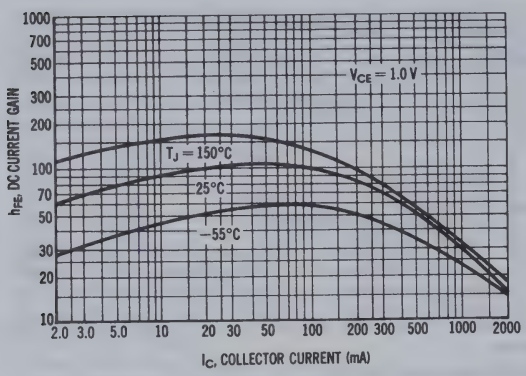


FIGURE 10 – COLLECTOR SATURATION REGION

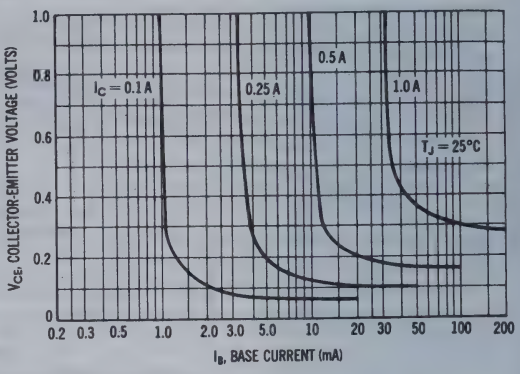


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

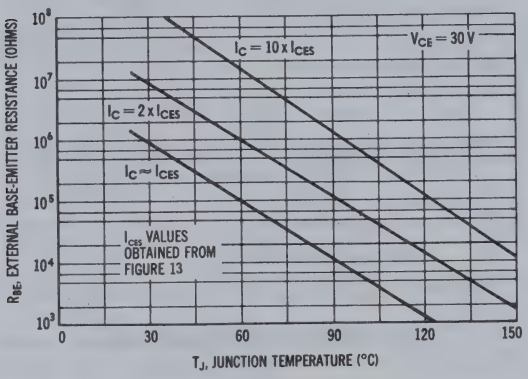


FIGURE 12 – "ON" VOLTAGE

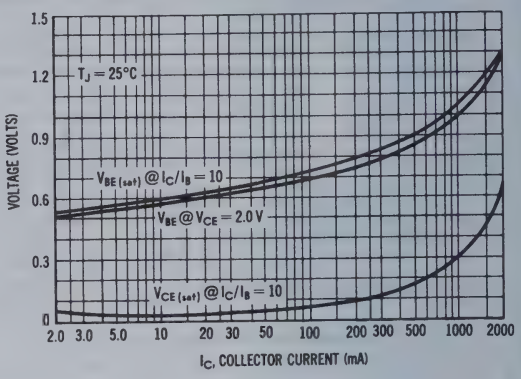


FIGURE 13 – COLLECTOR CUTOFF REGION

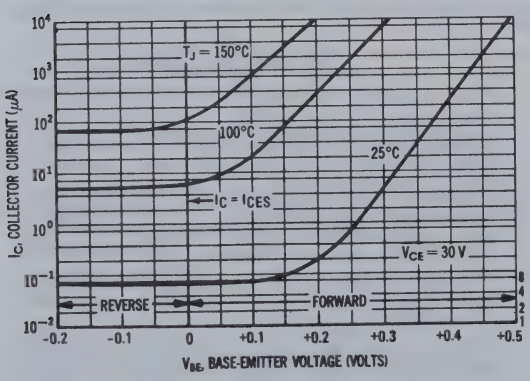
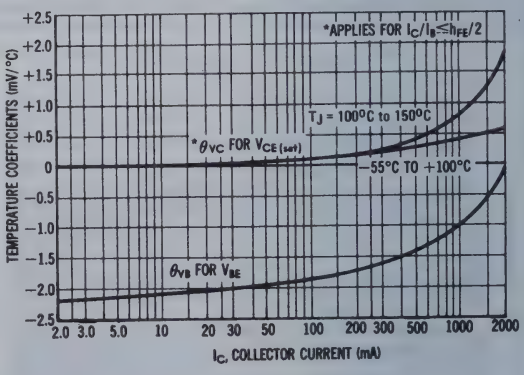


FIGURE 14 – TEMPERATURE COEFFICIENTS



MJE5190 thru MJE5192 (SILICON)

For Specifications, See 2N5190 Data.

MJE5193 thru MJE5195 (SILICON)

For Specifications, See 2N5193 Data.

MJE5655 thru MJE5657 (SILICON)

For Specifications, See 2N5655 Data.

MJE5974 thru MJE5976 (SILICON)

For Specifications, See 2N5974 Data.

MJE5977 thru MJE5979 (SILICON)

For Specifications, See 2N5977 Data.

MJE5980 thru MJE5982 (SILICON)

For Specifications, See 2N5980 Data.

MJE5983 thru MJE5985 (SILICON)

For Specifications, See 2N5983 Data.

MJE6040 thru MJE6045 (SILICON)

For Specifications, See 2N6040 Data.

MLED50
MLED55

VISIBLE RED LIGHT-EMITTING DIODES

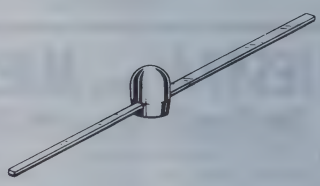
...designed for applications requiring high visibility, low-drive power and high reliability. These devices can be used as circuit status indicators, panel indicators in large matrix displays, and for film annotation. The MLED50 is a high intensity point source in a clear plastic package. The MLED55, because of its diffusing red plastic package appears as a large area light source with wide viewing angle.

- High Luminous Intensity – MLED50 – 1.0 mcd (Typ); MLED55 – 0.6 mcd (Typ)
- Solid State Reliability
- Compatible with IC's – Low Drive Current
- Economical Plastic Package – Clear or Diffusing Red
- Resistant to Shock and Vibration
- Wide Viewing Angle
- Easy Cathode Indentification – Wider Lead
- Visible Red Emission – 660 nM (Typ)

LIGHT-EMITTING DIODE
VISIBLE RED

GALLIUM ARSENIDE PHOSPHIDE

120 MILLIWATTS



MLED50 – Clear Plastic
MLED55 – Diffusing Red Plastic

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ $T_A = 25^oC$	P_D(1)	120	mW
Derate above 25^oC		2.0	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg} (2)	-40 to +85	^oC

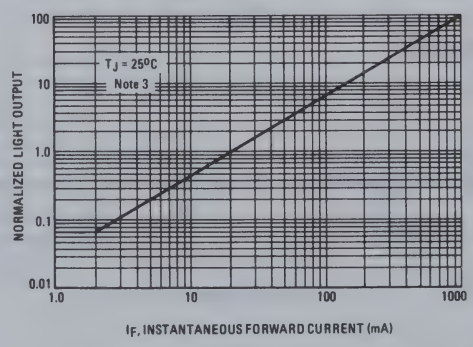
THERMAL CHARACTERISTICS

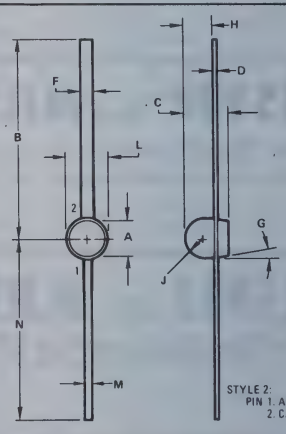
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}(1)	500	$^oC/W$
Solder Temperature	260^oC for 3 sec. – 1/16" from Case		

(1) Printed Circuit Board Mounting

(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85^oC.

FIGURE 1 – TYPICAL NORMALIZED LIGHT OUTPUT versus INSTANTANEOUS FORWARD CURRENT





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.083	0.093	2.11	2.36
B	0.445	0.450	11.30	11.43
C	0.094	0.104	2.39	2.64
D	0.008	0.012	0.203	0.305
F	0.026	0.028	0.660	0.711
G	9^0	11^0	9^0	11^0
H	0.062	0.072	1.57	1.83
J	0.040	0.045	1.02	1.14
L	0.092	0.102	2.34	2.59
M	0.019	0.021	0.483	0.533
N	0.405	0.410	10.29	10.41

CASE 234-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Instantaneous Luminous Intensity (I_F = 20 mA) Note 1	MLED50	1	I_o	0.5	1.0	–	mcd
	MLED55	1		0.3	0.6	–	
Brightness (I_F = 20 mA) Note 2	MLED50		B	–	750	–	fL
Peak Emission Wavelength			λp	–	660	–	nM
Spectral Line Half Width			Δλ	–	10	–	nM

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

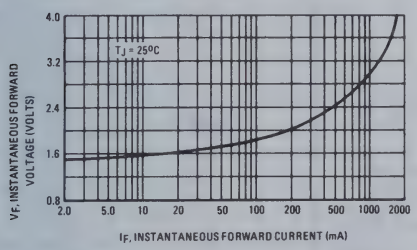


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

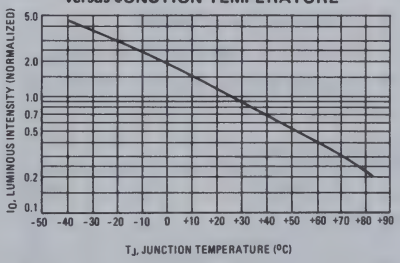


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

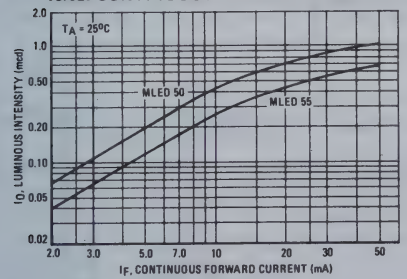
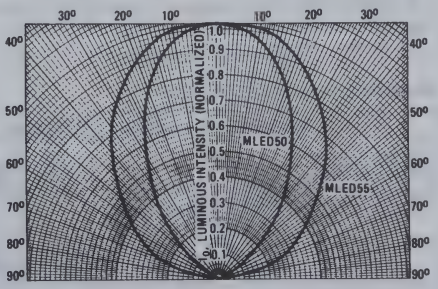


FIGURE 5 – SPATIAL RADIATION PATTERN



NOTES:

1. Axial Luminous Intensity (I_O) is measured using a Kerant K1100 Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_O is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_O is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design. The spatial radiation pattern and I_O clearly define the light emitting characteristics of an LED.

As seen from the specification, the MLED50 has a much higher I_O than the MLED55 because of the diffusing nature of the encapsulant used for the MLED55. The result is a large uniform field of emitted light for the MLED55 and a sharp intense field for the MLED50 as shown in Figure 5.

2. Brightness (B) measured with a Photo Research Spectra Spot Brightness Meter Model UB 1/4° with Spectra L-175 lens.

3. To estimate output level under non continuous current drive at junction temperature other than 25°C, first the average junction temperature can be calculated from

$$T_{J(av)} = T_A + \theta_{JA} \times V_F \times I_F \times D$$

where D is the duty cycle of the applied current (I_F). Then the normalized luminous intensity at this junction temperature can be read from Figure 3. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

*International Commission on Illumination

MLED60
MLED90

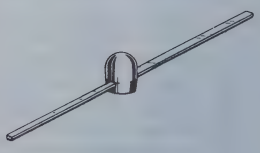


INFRARED-EMITTING DIODES

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card and tape readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Power Output – 550 μW (Typ) @ I_F = 50 mA – MLED60
  350 μW (Typ) @ I_F = 50 mA – MLED90
- Infrared Emission – 900 nM (Typ)
- Low Drive Current – Compatible with Integrated Circuits
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package
- Small Size for High Density Mounting
- Easy Cathode Identification – Wider Lead

INFRARED-EMITTING DIODES
900 nM
PN GALLIUM ARSENIDE
120 MILLIWATTS



MAXIMUM RATINGS

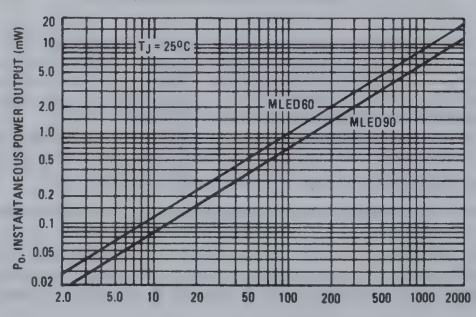
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,Tstg	-40 to +85	°C

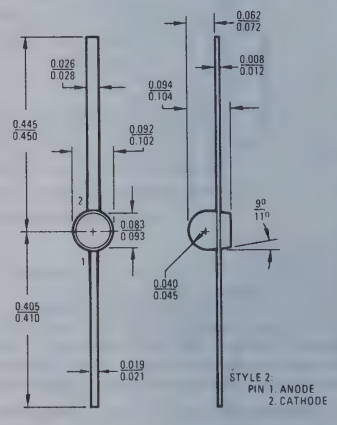
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	500	°C/W
Solder Temperature	260°C for 3 sec 1/16" from case		

(1)Printed Circuit Board Mounting

FIGURE 1 – INSTANTANEOUS POWER OUTPUT versus FORWARD CURRENT





CASE 234-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Instantaneous Power Output (Note 1) (I_F = 50 mA) MLED60	1	P_O	400	550	–	μW
MLED90			200	350	–	
Peak Emission Wavelength	–	λ_P	–	900	–	nM
Spectral Line Half Width	–	$\Delta\lambda$	–	40	–	nM

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.

FIGURE 2 – FORWARD CHARACTERISTICS

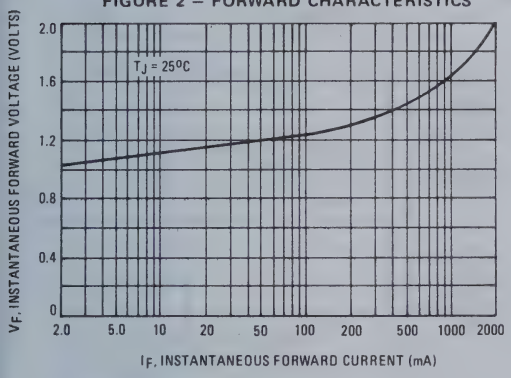


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

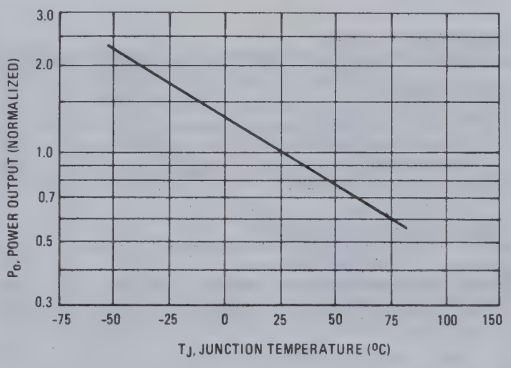


FIGURE 4 – CONTINUOUS POWER OUTPUT versus FORWARD CURRENT

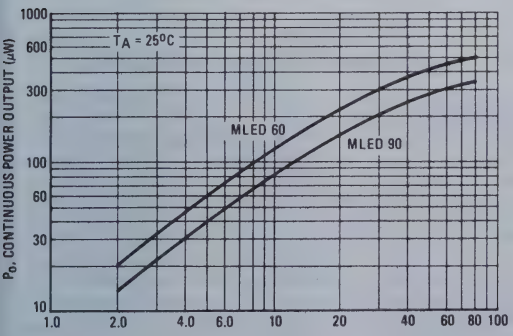
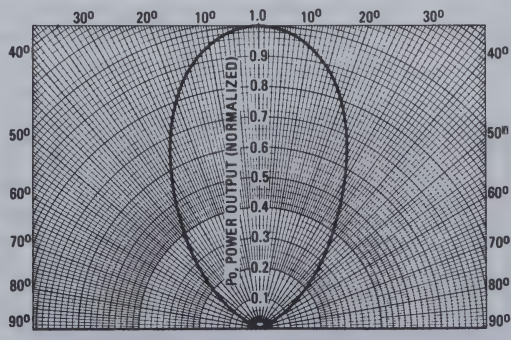


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 1. However, power output decreases due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

MLED92

INFRARED-EMITTING DIODE

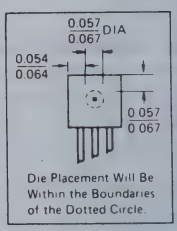
. . . designed for industrial processing and control applications such as light modulators, shaft or position encoders, end of tape detectors, and optical coupler applications. Supplied in TO-92 package for ease of mounting and compatibility with existing automatic insertion equipment.

- High Power Output—
  P_O = 150 μW (Typ) @ I_F = 50 mA
- Infrared-Emission — 9000 Å (Typ)
- One-Piece, Unibloc Package for High Reliability

LOW COST INFRARED-EMITTING DIODE

PN GALLIUM ARSENIDE





Die Placement Will Be Within the Boundaries of the Dotted Circle.

MAXIMUM RATINGS

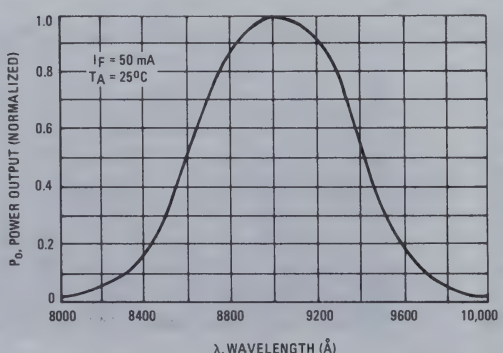
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	100	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	215 2.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +100	°C

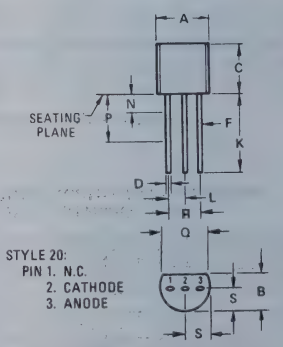
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	350	°C/W

(1) $R_{\theta JA}$(1) is measured with the device soldered into a typical printed circuit board.

FIGURE 1 — RELATIVE SPECTRAL OUTPUT





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Instantaneous Forward Voltage (Note 3) (I_F = 50 mA)	2	v_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Notes 1 and 3) (I_F = 50 mA)	3, 4	P_o	50	150	–	μW
Radiant Intensity (Note 2) (I_F = 50 mA)		I_o	–	0.66	–	mW/steradian
Peak Emission Wavelength	1	λP	–	9000	–	Å
Spectral Line Half Width	1	$\Delta\lambda$	–	400	–	Å

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

   $H = \frac{I_o}{d^2}$ where H is irradiance in mW/cm^2, I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.
3. Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%.

FIGURE 2 – FORWARD CHARACTERISTICS

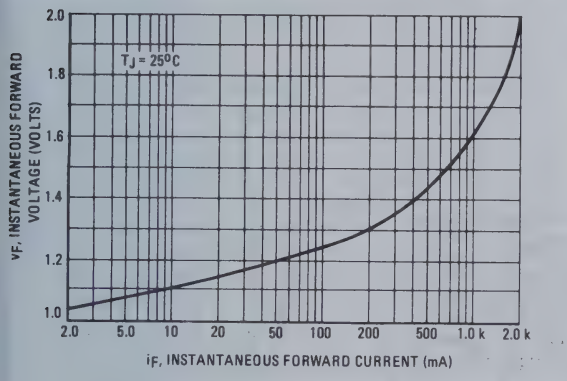


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

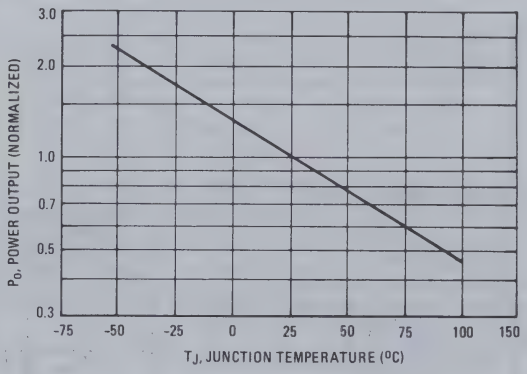


FIGURE 4 – INSTANTANEOUS POWER OUTPUT

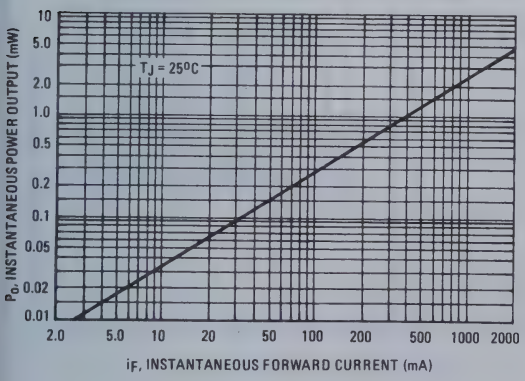
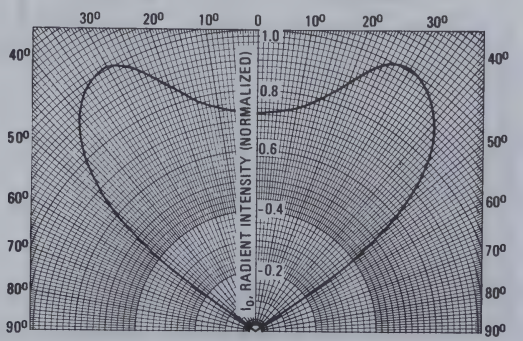


FIGURE 5 – SPATIAL RADIATION PATTERN



MLED455

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount applications where small size and plug-in package are desirable.

- High Luminous Intensity
- Solid State Reliability
- Diffusing Red Lens
- IC Compatible — Low Power Consumption
- Wide Viewing Angle — 90°

MINIATURE
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	30	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	60 1.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R\theta_{JA}$(1)	1000	°C/W

(1) $R_{\theta JA}$ is measured with the device socket mounted, with 1/8" lead from device to socket plane.



NOTE:
1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.68	3.94	0.145	0.155
B	2.92	3.18	0.115	0.125
C	4.95	5.21	0.195	0.205
D	0.38	0.48	0.015	0.019
E	0.76	1.02	0.030	0.040
F	0.20	0.30	0.008	0.012
G	2.41	2.67	0.095	0.105
J	1.78	2.03	0.070	0.080
K	12.70	–	0.500	–

CASE 292-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	1	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	2,3	I_o	0.3	1.2	– –	mcd
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1)Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 1 – FORWARD CHARACTERISTICS

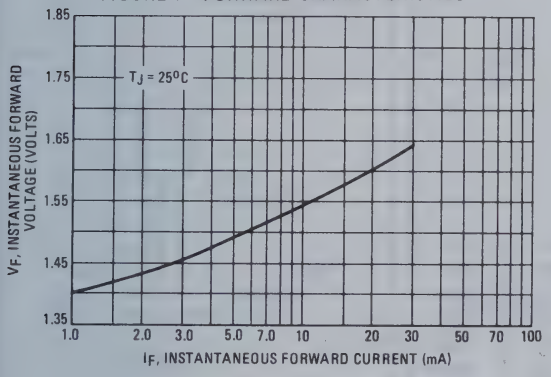


FIGURE 2 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

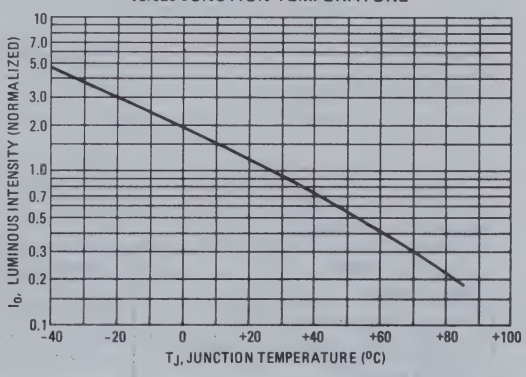


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

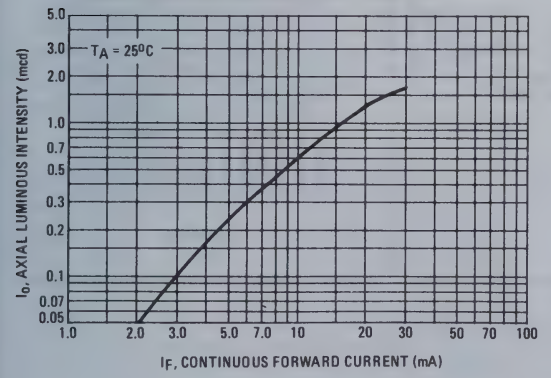
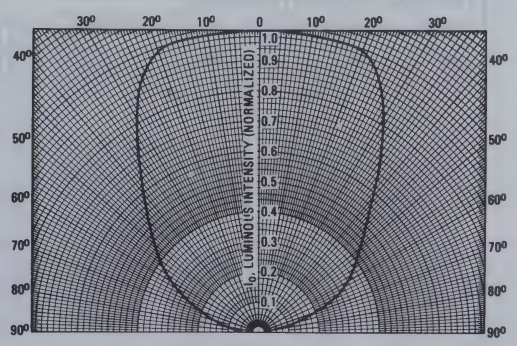


FIGURE 4 – SPATIAL RADIATION PATTERN



MLED500

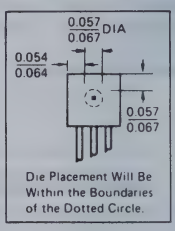
VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring visible indication of circuit status. Supplied in popular TO-92 package for ease of mounting into printed circuit board applications.

- Solid State Reliability
- Diffusing Red Lens
- IC Compatible — Low Power Consumption
- One-Piece, Injection-Molded Unibloc Package for High Reliability

LOW COST
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE





Die Placement Will Be Within the Boundaries of the Dotted Circle.

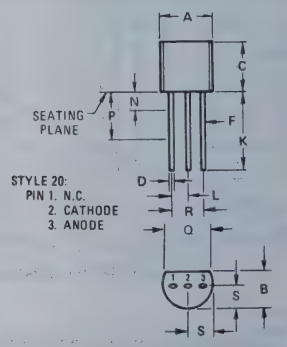
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	100	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	215 0.285	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +100	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R\theta_{JA}$(1)	350	°C/W

(1) $R\theta_{JA}$ is measured with the device soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	1	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	2,3	I_o	0.1	0.3	– –	mcd
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1)Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

TYPICAL CHARACTERISTICS

FIGURE 1 – FORWARD CHARACTERISTICS

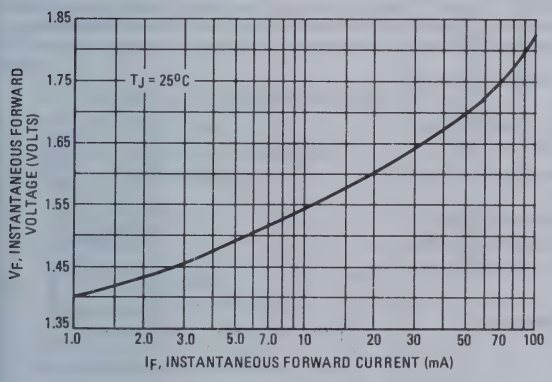


FIGURE 2 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

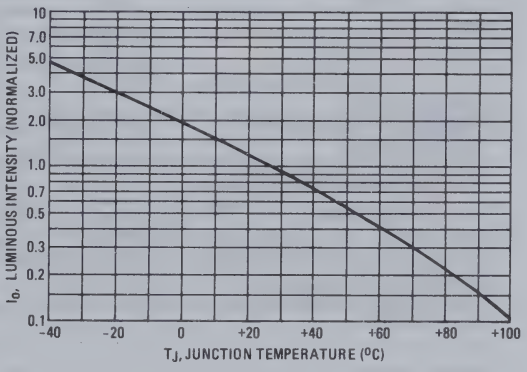


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

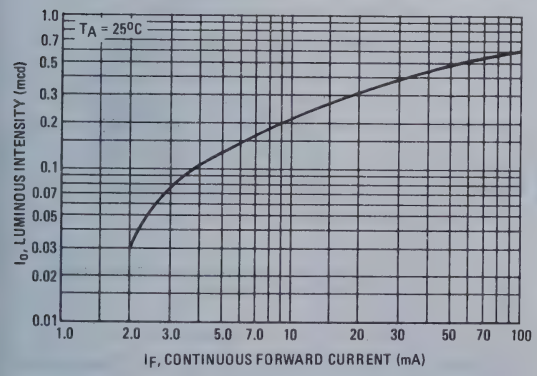
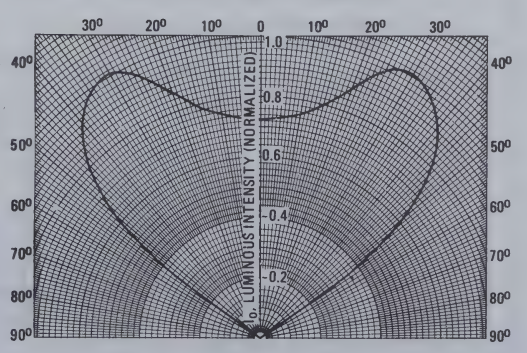


FIGURE 4 – SPATIAL RADIATION PATTERN



MLED600

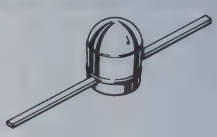
VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits.

- High Brightness – 1100 fL (Typ)
- Visible Red Emission – 6600 Å (Typ)
- Low Drive Current – 10 mA for 200 fL (Typ)
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE

120 MILLIWATTS



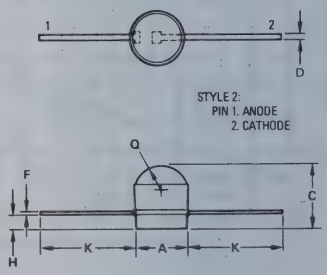
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}(2)	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	θ_{JA}	500	°C/W

(1) Printed Circuit Board Mounting
(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85°C.



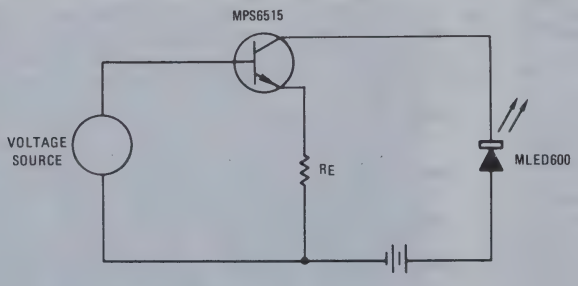
Lead 2 indicated by square bonding pad on bottom of device.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.56	4.06	0.140	0.160
C	4.57	5.33	0.180	0.210
D	0.33	0.48	0.013	0.019
F	0.23	0.28	0.009	0.011
H	1.02	1.27	0.040	0.050
K	6.35	–	0.250	–
Q	1.91 NOM		0.075 NOM	

Cathode indicated by square bonding pad on bottom of device.

CASE 171

FIGURE 1 – TYPICAL DRIVE CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Instantaneous Luminous Intensity (I_F = 20 mA)	–	I_o	1.0	3.0	–	mcd
Peak Emission Wavelength	4	λ_P	–	6600	–	Å
Spectral Line Half Width	4	$\Delta\lambda$	–	100	–	Å

NOTES:

1. Output saturation effects are not evident at pulse currents up to 2 A. However, saturation does occur due to heating of the semiconductor as indicated by Figure 5. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

2. Axial Luminous Intensity (I_O) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_O is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_O is a photometric measurement, it provides an accurate indication of the visibility of a LED that includes the physcial characteristics of the package such as encapsulant and lens design.

FIGURE 2 – FORWARD CHARACTERISTICS

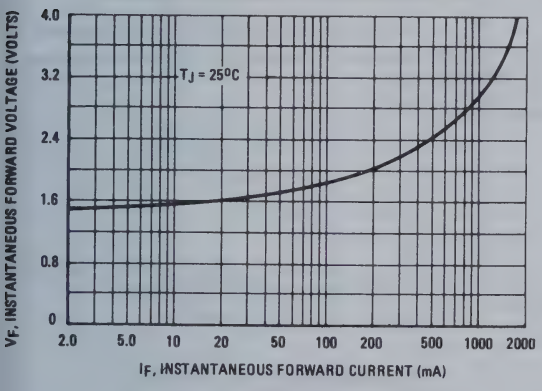


FIGURE 3 – LUMINOUS INTENSITY

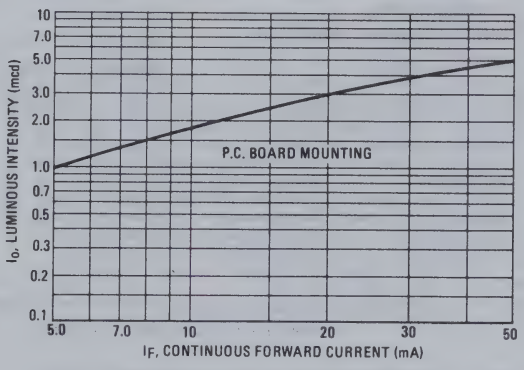


FIGURE 4 – RELATIVE INTENSITY

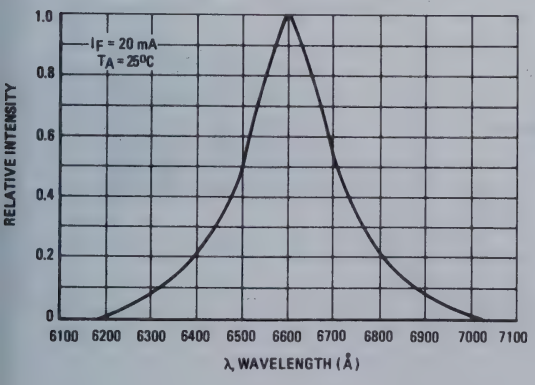
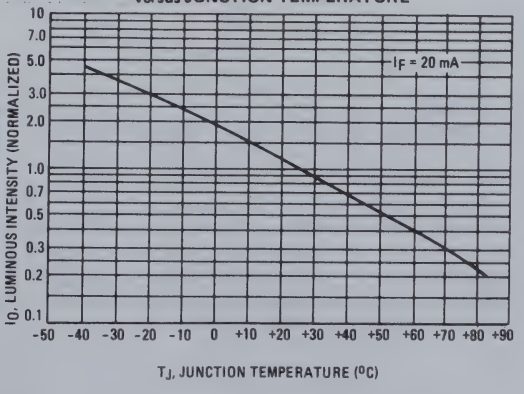


FIGURE 5 – LUMINOUS INTENSITY versus JUNCTION TEMPERATURE



MLED610

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical data links, optical switching, and logic circuits.

- High Brightness – 1100 fL (Typ)
- Visible Red Emission – 6600 Å (Typ)
- Low Drive Current – 10 mA for 200 fL (Typ)
- Hermetic Pill Package for Durability, Long Life and Reliability
- Pill Package Allows Printed Circuit Board Assembly
- Small Size for High Density Mounting

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE

350 MILLIWATTS



MAXIMUM RATINGS

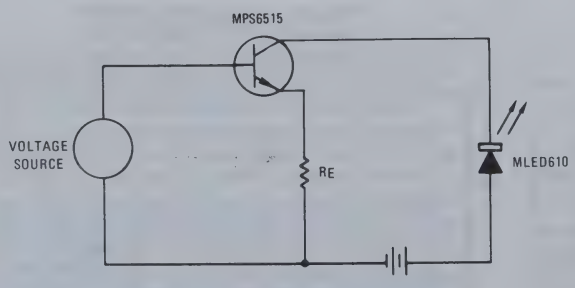
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	75	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	350 3.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +125	°C

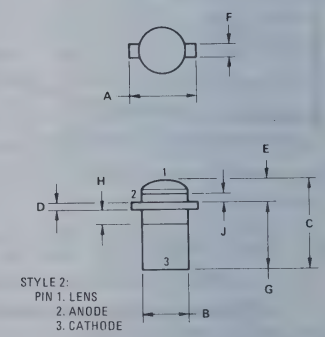
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient(1)	θ_{JA}	286	°C/W

(1) Thermal resistance, junction to case is typically 80° C/W. The mounting conditions determine the junction to ambient thermal resistance. For example, when soldered in a copper printed circuit board through a 1/8" diameter pad on the top to a 1/4" x 1/4" pad on the bottom surface, values of the 160° C/W will occur. If both pads are 1/8" in diameter, thermal resistance is typically 250° C/W; the limit of 286° C/W is specified for the latter mounting condition.

FIGURE 1 – TYPICAL DRIVE CIRCUIT





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.083	0.093	2.110	2.360
B	0.058	0.062	1.470	1.570
C		0.125		3.180
D	0.003	0.007	0.076	0.178
E	0.023	0.029	0.584	0.737
F	0.018	0.022	0.457	0.559
G	0.082	0.094	2.080	2.390
H	0.014	0.020	0.356	0.508
J	0.008	0.012	0.203	0.305

CASE 81A-03

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	1.8	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Instantaneous Brightness (Note 1) (I_F = 10 mA) (I_F = 50 mA)	3	B	50 –	200 1100	– –	fL
Axial Instantaneous Luminous Intensity		I_o	–	3.0	–	mcd
Peak Emission Wavelength	4	λ_P	–	6600	–	Å
Spectral Line Half Width	4	$\Delta\lambda$	–	100	–	Å
Angular Field of View (Measured Between Half Power Points)	–	θ_{FV}	–	120	–	Degrees

NOTE:

1. Measured with Photo Research Spectra Spot Brightness Meter Model UB 1/4° with "Spectar" L-175 lens.
2. Output saturation effects are not evident at currents up to 2 A as shown on Figure 3. However, saturation does occur due to heating of the semiconductor as indicated by Figure 5. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

FIGURE 2 – FORWARD CHARACTERISTICS

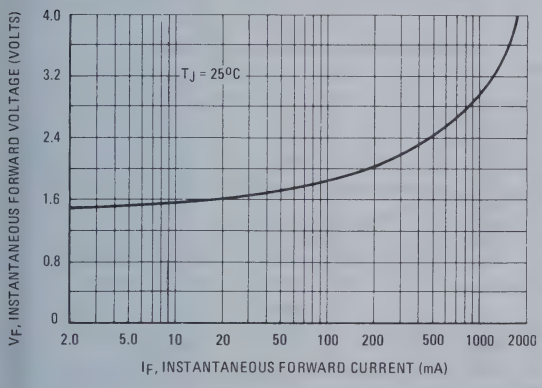


FIGURE 3 – INSTANTANEOUS BRIGHTNESS

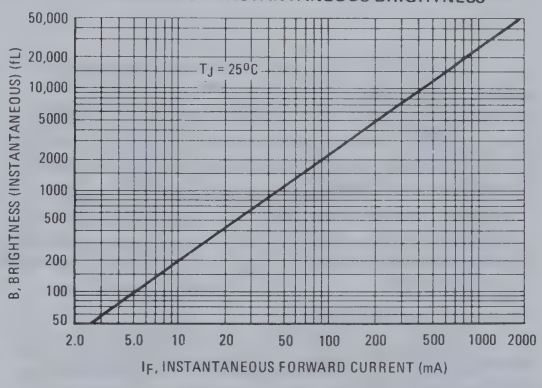


FIGURE 4 – RELATIVE INTENSITY

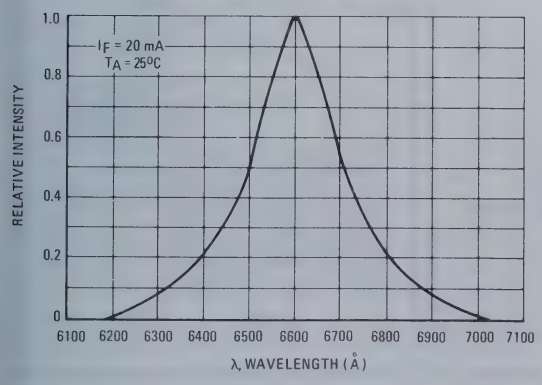
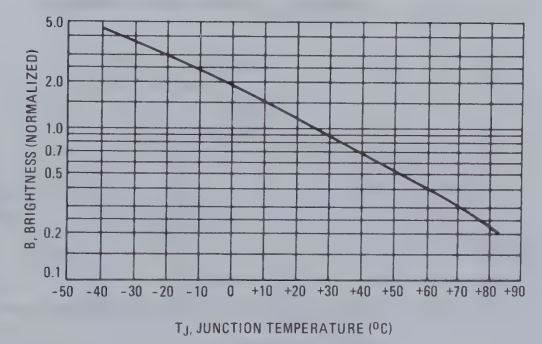


FIGURE 5 – BRIGHTNESS versus JUNCTION TEMPERATURE



MLED630

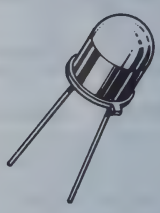


VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits.

- High Brightness – 1100 fL (Typ)
- Visible Red Emission – 6600 Å (Typ)
- Low Drive Current – 10 mA for 200 fL (Typ)
- Wide Field of View – 120° (Typ)
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package
- Popular TO-18 Type Package for Easy Handling and Mounting

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE
150 MILLIWATTS



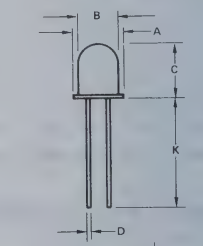
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	75	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	150 2.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	θ_{JA}(1)	400	°C/W

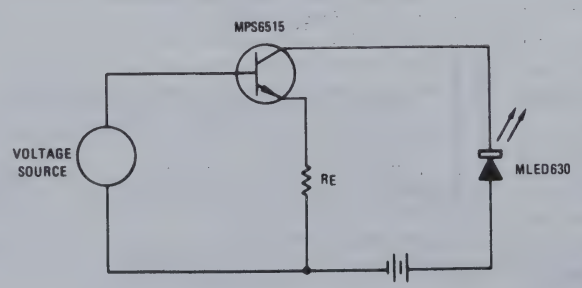
(1)Printed Circuit Board Mounting



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.70	5.33	0.185	0.210
C	5.08	5.72	0.200	0.225
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	

CASE 247

FIGURE 1 – TYPICAL DRIVE CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	1.8	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Instantaneous Brightness (Note 1) (I_F = 10 mA) (I_F = 50 mA)	3	B	50 –	200 1100	– –	fL
Axial Instantaneous Luminous Intensity		I_o	–	4.0	–	mcd
Peak Emission Wavelength	4	λ_P	–	6600	–	Å
Spectral Line Half Width	4	$\Delta\lambda$	–	100	–	Å
Angular Field of View (Measured Between Half Power Points)	–	θ_{FV}	–	120	–	Degrees

NOTE:

1. Measured with Photo Research Spectra Spot Brightness Meter Model UB 1/4° with "Spectar" L 175 lens
2. Output saturation effects are not evident at currents up to 2 A as shown on Figure 3. However, brightness decreases due to heating of the semiconductor as indicated by Figure 5. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

FIGURE 2 – FORWARD CHARACTERISTICS

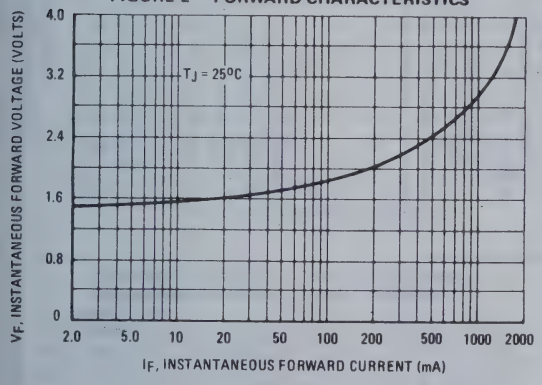


FIGURE 3 – INSTANTANEOUS BRIGHTNESS

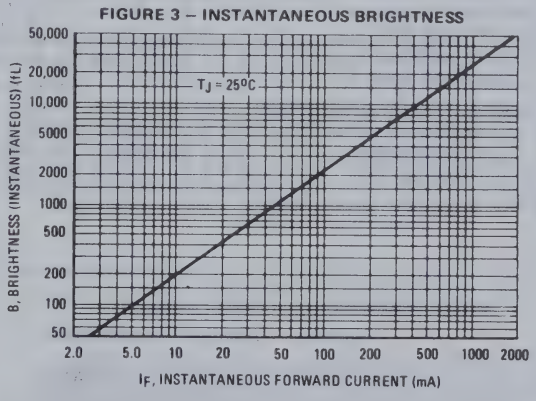


FIGURE 4 – RELATIVE INTENSITY

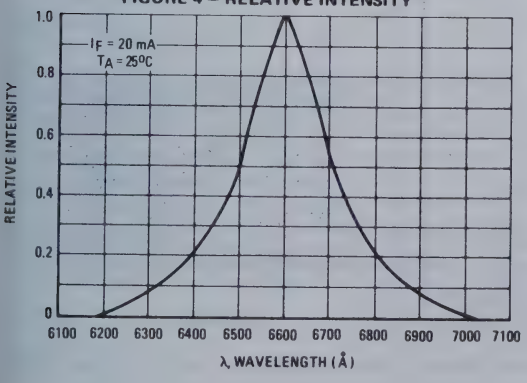
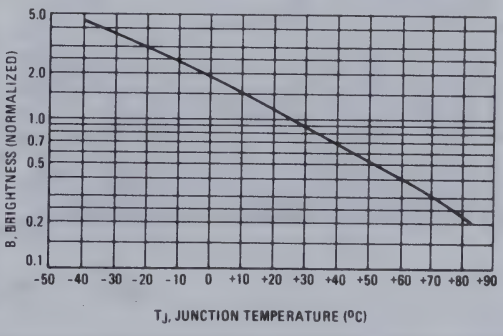


FIGURE 5 – BRIGHTNESS versus JUNCTION TEMPERATURE



MLED640

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Intended for mounting in standard 0.125" panels using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Wide Viewing Angle – 90°
- Clear Diffusing Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



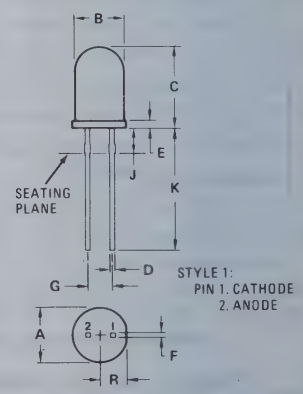
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	600	°C/W

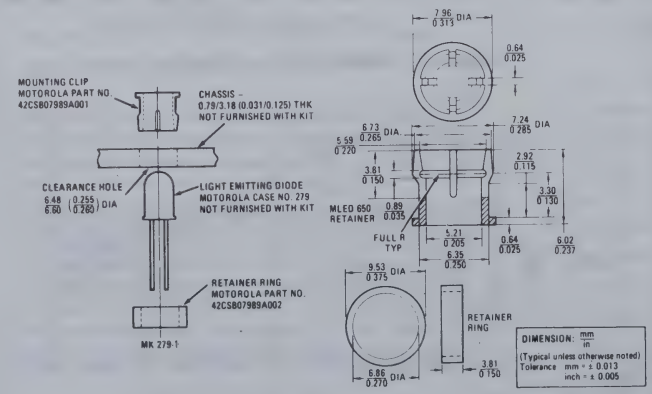
(1)Mounted in metal panel (see Figure 1)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

FIGURE 1 – HARDWARE DIMENSIONS



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_o	0.8	2.0	–	mcd
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1)Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

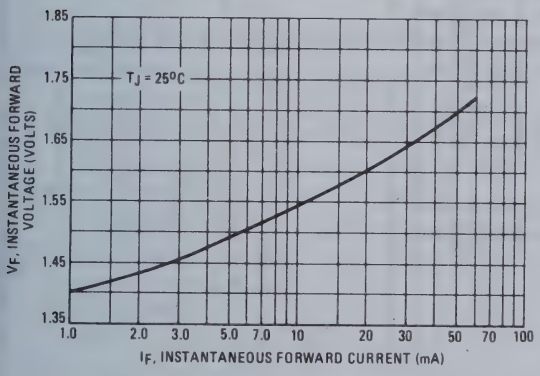


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

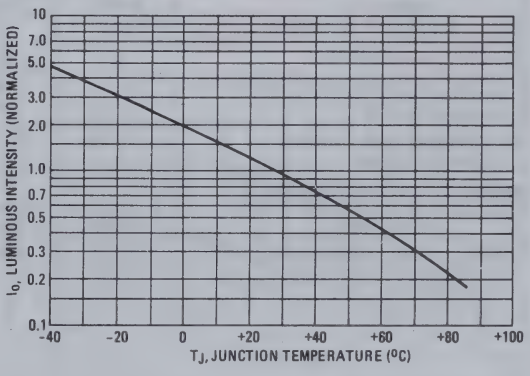


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

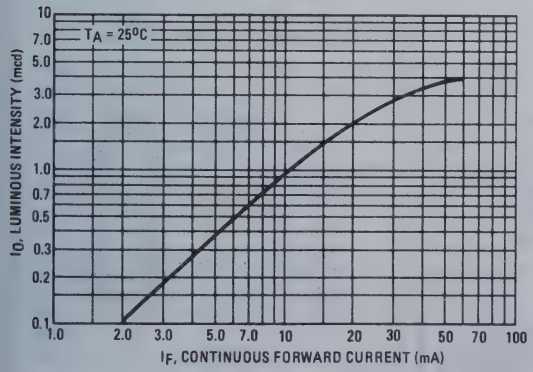
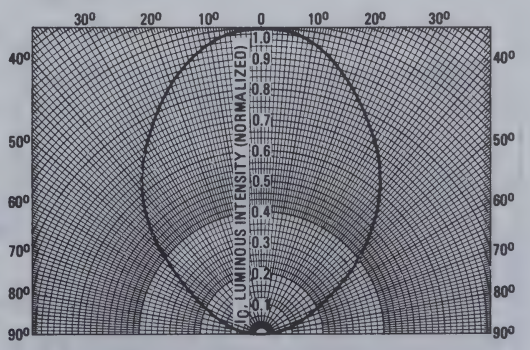


FIGURE 5 – SPATIAL RADIATION PATTERN



MLED650

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Intended for mounting in standard 0.125" panels using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Wide Viewing Angle – 140°
- Diffusing Red Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



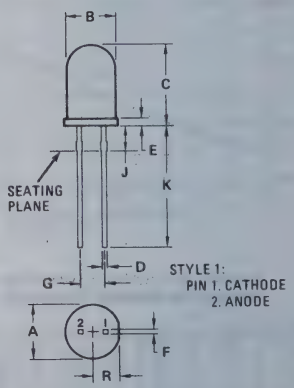
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	θ_{JA}(1)	600	°C/W

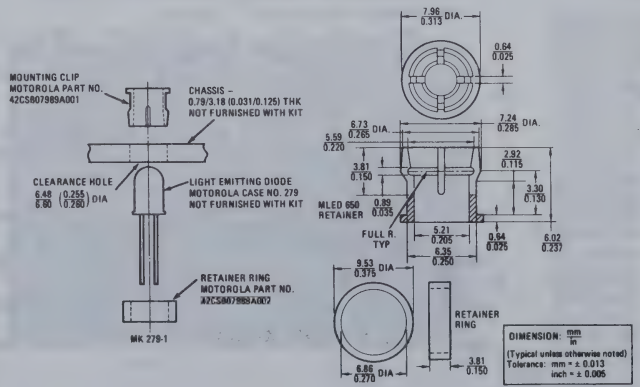
(1)Mounted in metal panel (see Figure 1)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

FIGURE 1 – HARDWARE DIMENSIONS



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1)	3,4	I_o				mcd
(IF = 20 mA)			0.3	0.8	–	
(IF = 50 mA)			–	1.4	–	
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1)Axial Luminous Intensity (I_o) is measured using a Kerant K1100 Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design. The spatial radiation pattern and I_o clearly define the light emitting characteristics of an LED.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

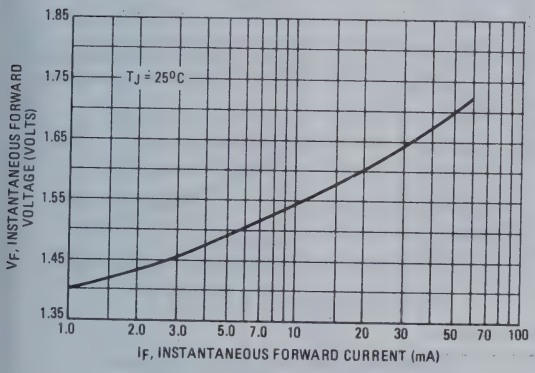


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

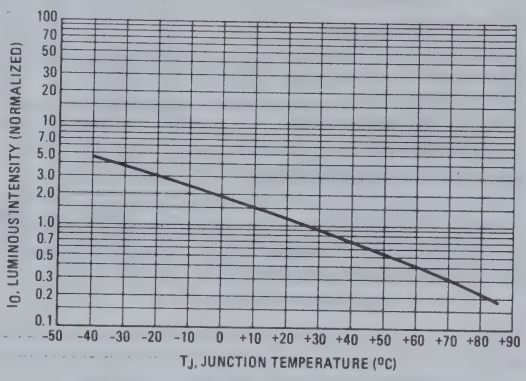


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

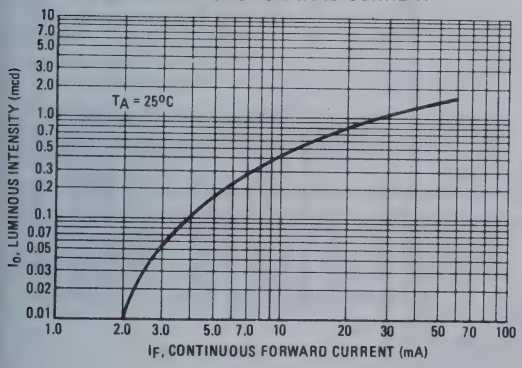
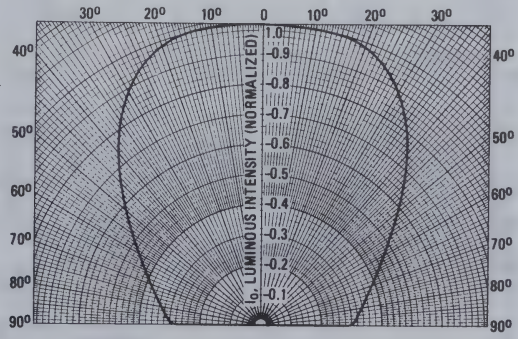


FIGURE 5 – SPATIAL RADIATION PATTERN



MLED655

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Intended for mounting in standard 0.125" panels using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Wide Viewing Angle – 90°
- Red Diffusing Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



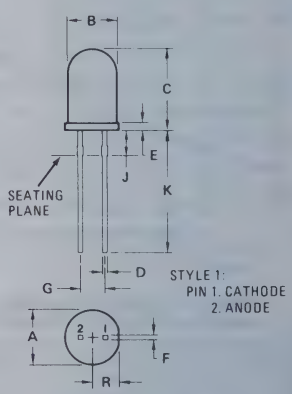
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	θ_{JA}(1)	600	°C/W

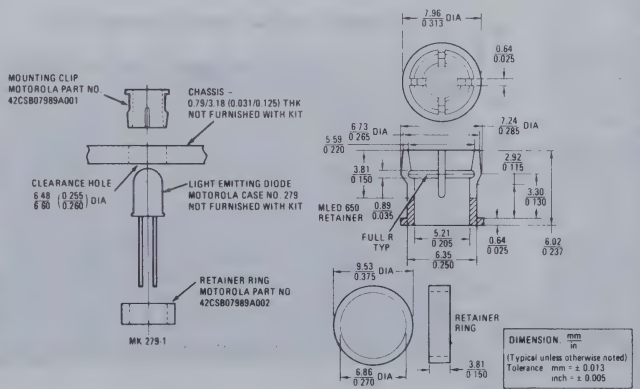
(1)Mounted in metal panel (see Figure 1)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

FIGURE 1 – HARDWARE DIMENSIONS



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_o	0.8	2.0	–	mcd
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1)Axial Luminous Intensity (I_o) is measured using a Kerant K1100 Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design. The spatial radiation pattern and I_o clearly define the light emitting characteristics of an LED.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

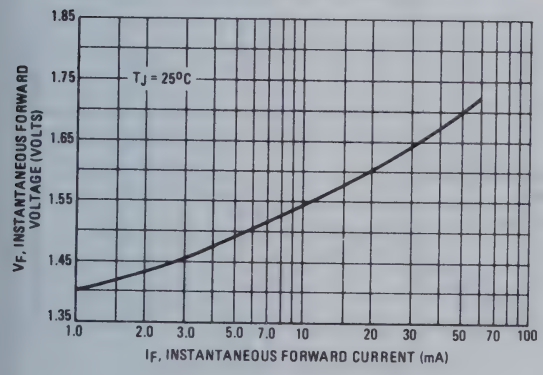


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

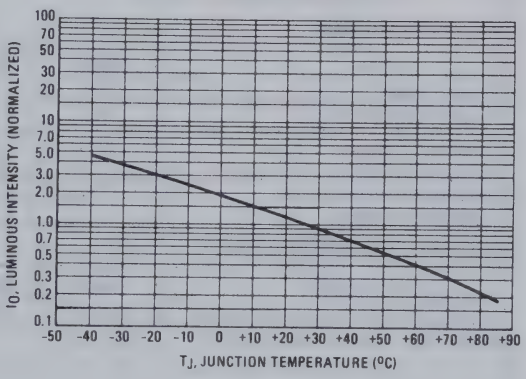


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

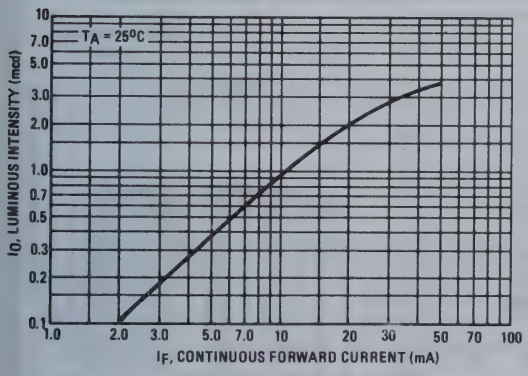
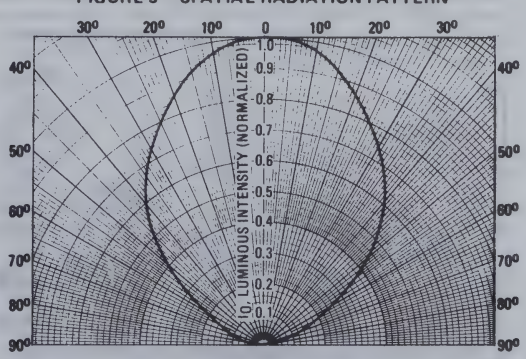


FIGURE 5 – SPATIAL RADIATION PATTERN



MLED750

VISIBLE GREEN LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Intended for mounting in standard 0.125" panels using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Wide Viewing Angle – 90°
- Green Diffusing Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE GREEN
PN GALLIUM PHOSPHIDE



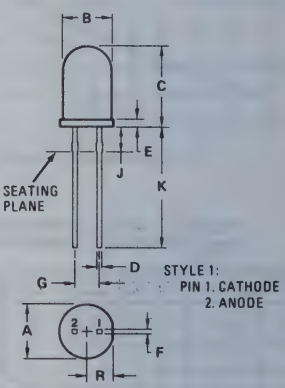
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	30	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	600	°C/W

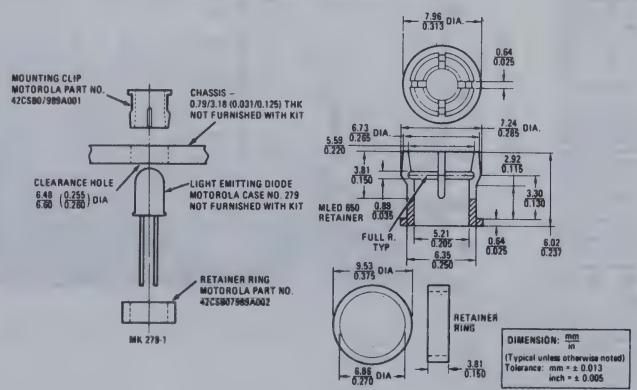
(1)Mounted in metal panel (see Figure 1)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

FIGURE 1 – HARDWARE DIMENSIONS



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Instantaneous Forward Voltage (1) (I_F = 25 mA)	2	V_F	–	2.1	3.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (2) (I_F = 25 mA)	3,4	I_o	0.3	0.5	–	mcd
Peak Emission Wavelength	–	λp	–	5600	–	Å
Spectral Line Half Width	–	Δλ	–	350	–	Å

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≦ 2.0%

(2) Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

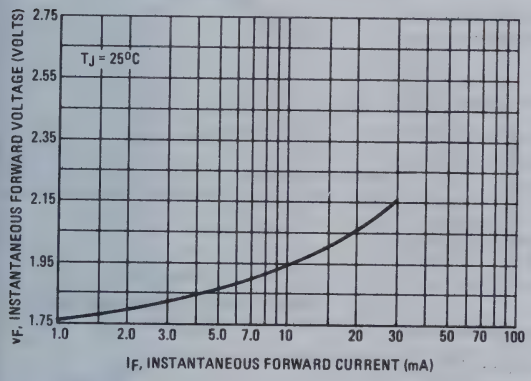


FIGURE 3 – EFFECTS OF JUNCTION TEMPERATURE ON AXIAL LUMINOUS INTENSITY

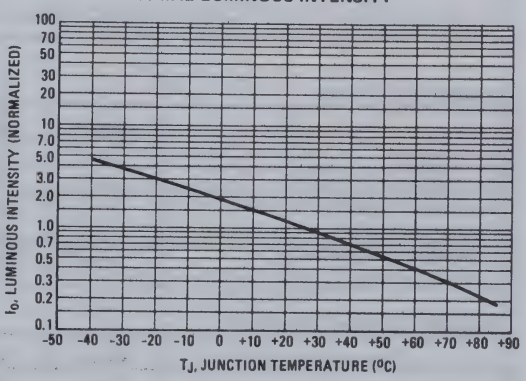


FIGURE 4 – EFFECTS OF FORWARD CURRENT ON AXIAL LUMINOUS INTENSITY

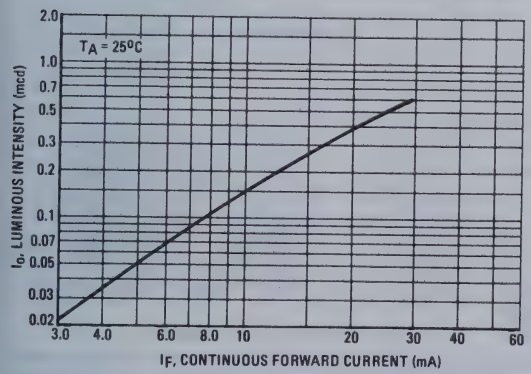
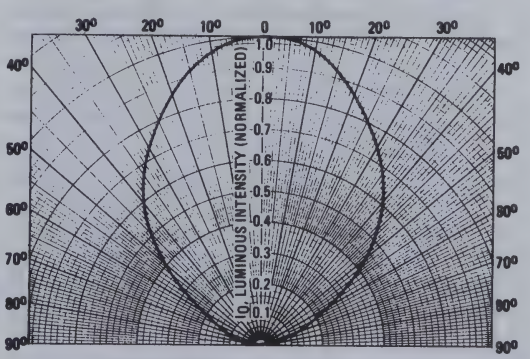


FIGURE 5 – SPATIAL RADIATION PATTERN



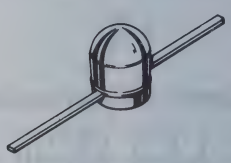
MLED900

INFRARED-EMITTING DIODE

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Power Output — 550 μW (Typ) @ I_F = 50 mA
- Infrared Emission — 9000 Å (Typ)
- Low Drive Current — 10 mA for 120 μW (Typ)
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package

INFRARED-EMITTING DIODE
9000 Å
PN GALLIUM ARSENIDE
120 MILLIWATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg} (2)	-40 to +85	°C

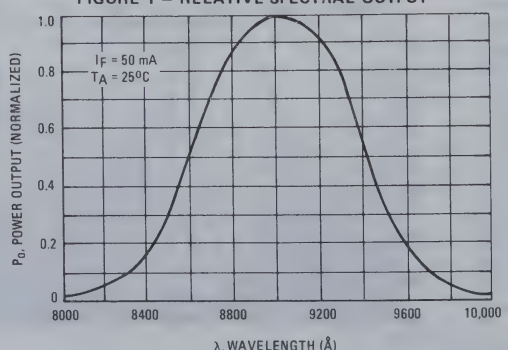
THERMAL CHARACTERISTICS

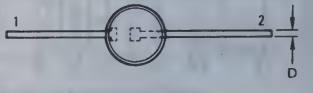
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	500	°C/W

(1) Printed Circuit Board Mounting

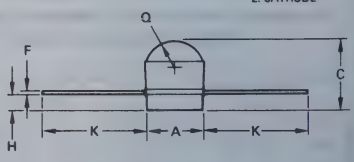
(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85°C.

FIGURE 1 — RELATIVE SPECTRAL OUTPUT





STYLE 2:
PIN 1. ANODE
2. CATHODE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.56	4.06	0.140	0.160
C	4.57	5.33	0.180	0.210
D	0.33	0.48	0.013	0.019
F	0.23	0.28	0.009	0.011
H	1.02	1.27	0.040	0.050
K	6.35	–	0.250	–
Q	1.91 NOM		0.075 NOM	

CASE 171

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) (I_F = 50 mA)	3, 4	P_o	200	550	–	μW
Radiant Intensity (Note 2) (I_o = 10 mA)		I_o	–	2.4	–	mW/steradian
Peak Emission Wavelength	1	λ_P	–	9000	–	Å
Spectral Line Half Width	1	$\Delta\lambda$	–	400	–	Å

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$

where H is irradiance in mW/cm^2, I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 – FORWARD CHARACTERISTICS

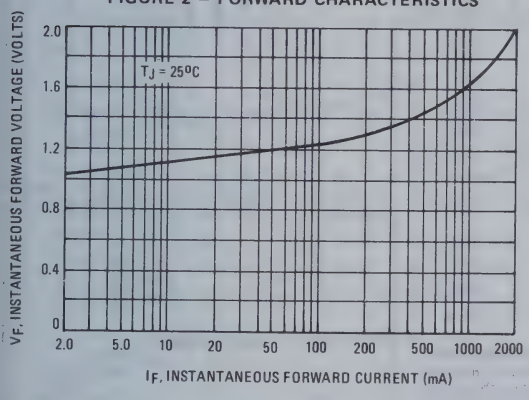


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

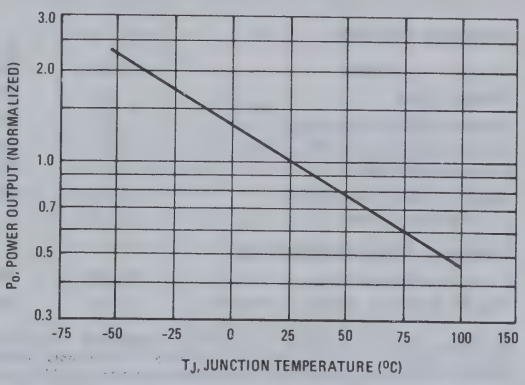


FIGURE 4 – INSTANTANEOUS POWER OUTPUT versus FORWARD CURRENT

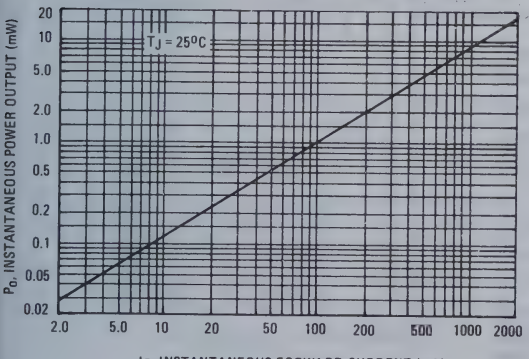
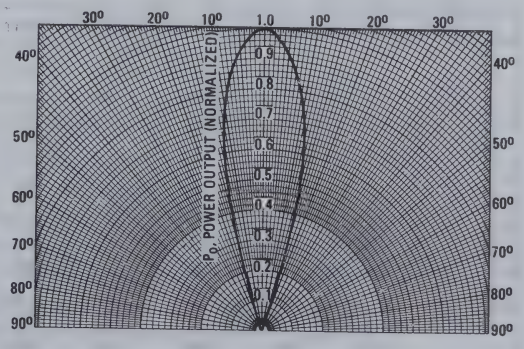


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

MLED910

INFRARED-EMITTING DIODE

. . . designed for applications requiring high density mounting, high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card and tape readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Power Output — 150 μW (Typ) @ I_F = 50 mA
- Infrared-Emission — 9000 Å (Typ)
- Low Drive Current — 10 mA for 32 μW (Typ)
- Low Profile Pill Package Allows Printed Circuit Board Assembly
- Sub-Miniature Package for High Density Mounting

INFRARED-EMITTING DIODE
9000 Å
PN GALLIUM ARSENIDE
350 MILLIWATTS



MAXIMUM RATINGS

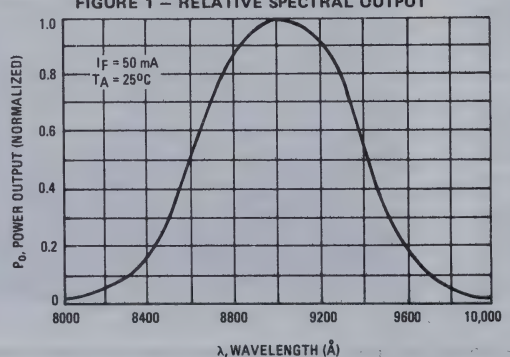
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	150	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	350 3.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +125	°C

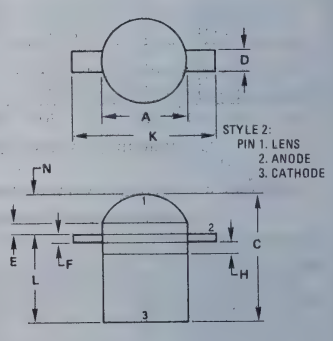
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	286	°C/W

(1) Thermal resistance, junction to case is typically 80°C/W. The mounting conditions determine the junction to ambient thermal resistance. For example, when soldered in a copper printed circuit board through a 1/8" diameter pad on the top to a 1/4" x 1/4" pad on the bottom surface, values of 160°C/W will occur. If both pads are 1/8" in diameter, thermal resistance is typically 250°C/W; the limit of 286°C/W is specified for the latter mounting condition.

FIGURE 1 — RELATIVE SPECTRAL OUTPUT





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.47	1.57	0.058	0.062
C	--	3.18	--	0.125
D	0.46	0.56	0.018	0.022
E	0.20	0.30	0.008	0.012
F	0.08	0.18	0.003	0.007
H	0.36	0.51	0.014	0.020
K	2.11	2.36	0.083	0.093
L	2.08	2.39	0.082	0.094
N	0.58	0.79	0.023	0.031

CASE 81A-03

Cathode connected to case

MLED910 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) (I_F = 50 mA)	3, 4	P_o	50	150	–	μW
Radiant Intensity (Note 2) (I_F = 50 mA)		I_o	–	0.66	–	mW/steradian
Peak Emission Wavelength	1	λ_P	–	9000	–	Å
Spectral Line Half Width	1	$\Delta\lambda$	–	400	–	Å

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$

where H is irradiance in mW/cm^2, I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 – FORWARD CHARACTERISTICS

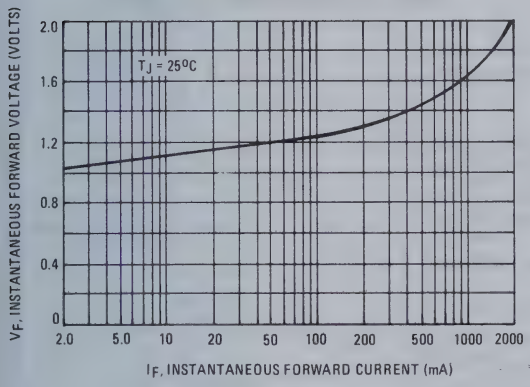


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

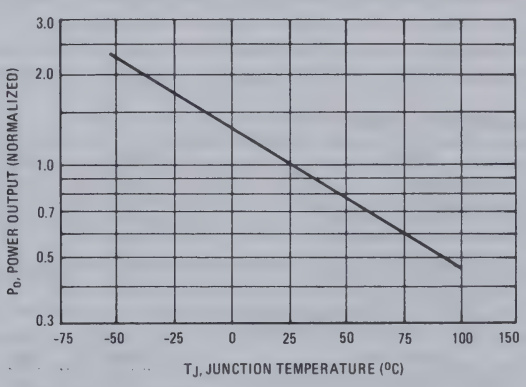


FIGURE 4 – INSTANTANEOUS POWER OUTPUT

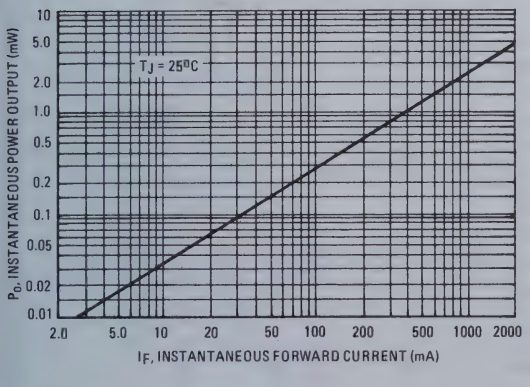
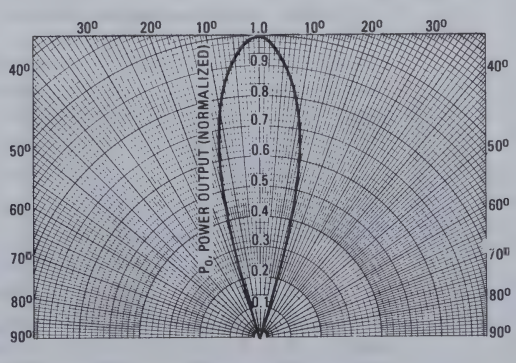


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

MLED930

INFRARED-EMITTING DIODE

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High-Power Output – 650, μW (Typ) @ I_F = 100 mA
- Infrared-Emission – 9000 Å (Typ)
- Low Drive Current – 10 mA for 70 μW (Typ)
- Popular TO-18 Type Package for Easy Handling and Mounting
- Hermetic Metal Package for Stability and Reliability

INFRARED-EMITTING DIODE
9000 Å
PN GALLIUM ARSENIDE

250 MILLIWATTS

CONVEX LENS



MAXIMUM RATINGS

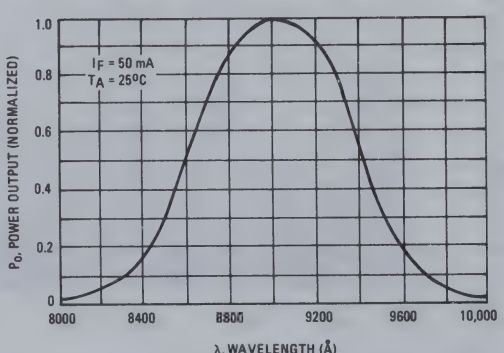
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	150	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	250 2.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +125	°C

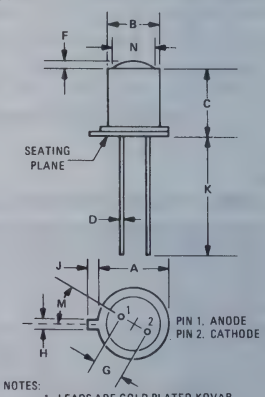
THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Juntion to Ambient	θ_{JA}	400	°C/W

(1)Printed Circuit Board Mounting

FIGURE 1 – RELATIVE SPECTRAL OUTPUT





NOTES:
1 - LEADS ARE GOLD PLATED KOVAR
2 - CATHODE CONNECTED TO CASE
3 - PKG. WT. ≈ 0.45 GRAMS.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	5.33
D	0.016	0.019	0.406	0.483
F	0.020	0.040	0.508	1.02
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.7	
M	45°		45°	
N	0.132	0.158	3.35	4.01

CASE 209

MLED930 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) (I_F = 50 mA)	3, 4	P_o	200	650	–	μW
Radiant Intensity (Note 2) (I_F = 100 mA)		I_o	–	1.5	–	mW/steradian
Peak Emission Wavelength	1	λ_P	–	9000	–	Å
Spectral Line Half Width	1	$\Delta\lambda$	–	400	–	Å

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$

where H is irradiance in mW/cm^2; I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 – FORWARD CHARACTERISTICS

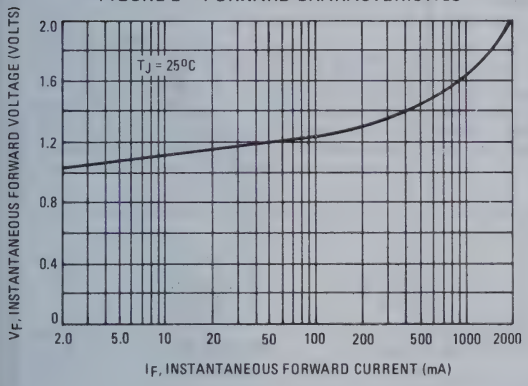


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

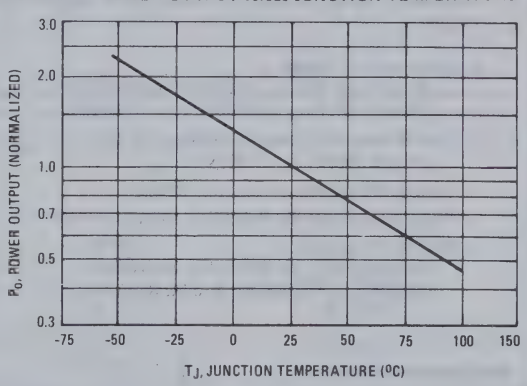


FIGURE 4 – INSTANTANEOUS POWER OUTPUT versus FORWARD CURRENT

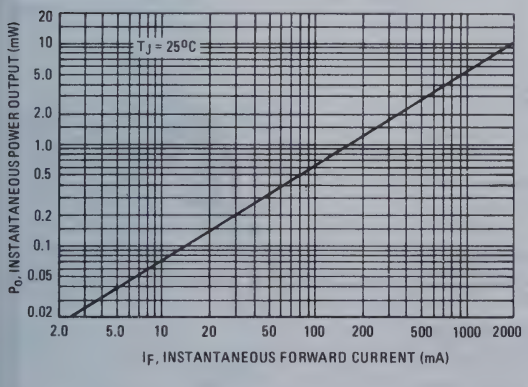
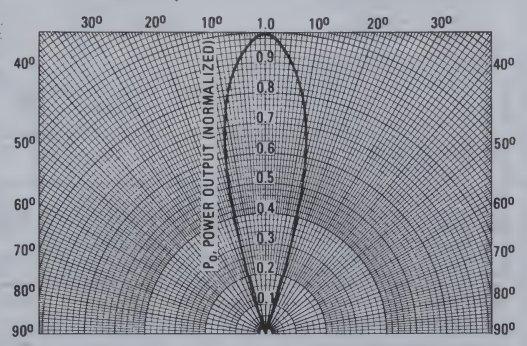


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

MLS101 thru MLS105 (SILICON)
MLS201 thru MLS205

Advance Information



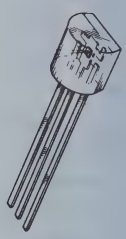
LIGHT SENSITIVE THYRISTORS

. . .Annular♦ PNPN devices designed for applications such as optoelectronic couplers, relay and lamp drivers, small motor controllers, drivers for larger thyristors, and in sensing and detection circuits.

- Sensitive Gate Trigger –
  35 mW/cm^2 (Typ) – MLS101 thru MLS105
  10 mW/cm^2 (Typ) – MLS201 thru MLS205
- Low Reverse and Forward Blocking Current –
  100 μA (Max), T_C = 100°C
- Low Holding Current – 2.0 mA (Max)
- Passivated Surface for Reliability and Uniformity
- Choice of Packages –
  Plastic TO-92 – MLS101 thru MLS105
  Metal TO-18 – MLS201 thru MLS205

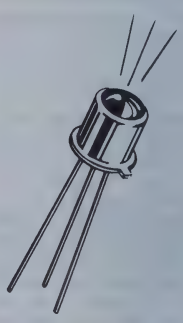
LIGHT ACTIVATED SILICON CONTROLLED RECTIFIERS

250, 400 mA RMS
15 thru 200 VOLTS



CASE 29-01
TO-92

MLS101 thru
MLS105



CASE 82
TO-18

MLS201 thru
MLS205

MAXIMUM RATINGS

Rating	Symbol	MLS101 Series	MLS201 Series	Unit
Peak Reverse Blocking Voltage MLS101, MLS201 MLS102, MLS202 MLS103, MLS203 MLS104, MLS204 MLS105, MLS205	V_{RRM}	15 30 60 100 200		Volts
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	250	400	mA
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	5.0		Amp
Average Gate Current – Forward, T_A = 25°C	$I_{GF(AV)}$	25		mA
Peak Gate Current – Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	500		mA
Peak Gate Voltage – Reverse	V_{GRM}	6.0		Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-40 to +100		°C
Storage Temperature Range	T_{stg}	-40 to +100		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient MLS101 Series	θ_{JA}	200	°C/W
Thermal Resistance, Junction to Case MLS201 Series	θ_{JC}	150	°C/W

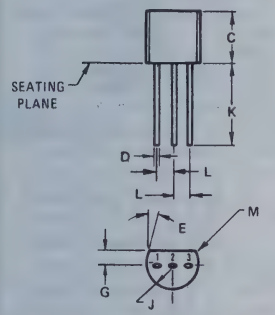
♦Annual Semiconductors Patented by Motorola, Inc.

This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (R_{GK} = 15 k Ohms, T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 100°C	MLS101, MLS201	V_{DRM}	15	–	Volts
	MLS102, MLS202		30	–	
	MLS103, MLS203		60	–	
	MLS104, MLS204		100	–	
	MLS105, MLS205		200	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 100°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 100°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2)		V_{TM}			Volts
(I_{TM} = 250 mA)	MLS101 thru MLS105		–	1.8	
(I_{TM} = 400 mA)	MLS201 thru MLS205		–	1.7	
Light Sensitivity (V_{AK} = 7.0 V, Tungsten Source @ 2780°K)		H_{ET}			mW/cm²
	MLS101 thru MLS105		–	50	
	MLS201 thru MLS205		–	20	
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms, T_C = 25°C)		I_{GT}	–	100	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	V_{GT}	–	0.8	Volts
	T_C = 100°C	V_{GD}	0.1	–	
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C	I_H	–	2.0	mA

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

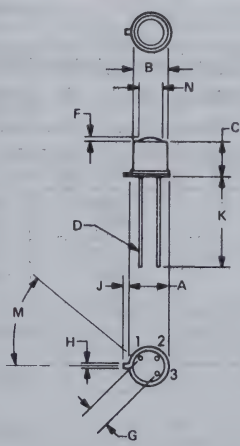


MLS101 thru MLS105

CASE 29-01
TO-92

Pin 1. Gate
2. Anode
3. Cathode

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	5° NOM		5° NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330



NOTES: Leads are gold-plated kovar
Anode internally connected to case
Package weight ≈ 0.45 grams

MLS201 thru MLS205

CASE 82
TO-18

Pin 1. Cathode
2. Gate
3. Anode

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	4.33
D	0.016	0.019	0.406	0.483
F	0.020	0.040	0.508	1.02
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.70	
M	45°		45°	
N	0.132	0.158	3.35	4.01

MM869B (SILICON)
2N869A
2N4453

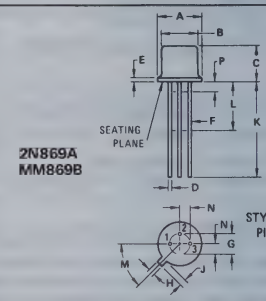
PNP SILICON ANNULAR TRANSISTORS

. . . designed for high speed, low power, saturated switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 18 Vdc (Min) — 2N869A, 2N4453
  = 30 Vdc (Min) — MM869B
- JAN/JANTX/JANTXV Available for 2N869A and 2N4453
- Glass Passivated Die
- Switching Times @ I_C = 30 mAdc, I_C/I_B = 10
  t_{on} = 9.0 ns (Typ)
  t_{off} = 44 ns (Typ)

SWITCHING TRANSISTORS

PNP SILICON



2N869A
MM869B

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 22-03
(TO-18)

All JEDEC notes and dimensions apply.

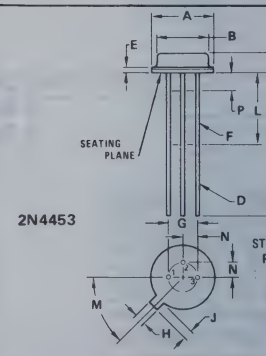
MAXIMUM RATINGS

Rating	Symbol	2N869A	MM869B	2N4453	Unit
*Collector-Emitter Voltage	V_{CEO}	18	30	18	Vdc
*Collector-Base Voltage	V_{CB}	25	30	25	Vdc
*Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
*Collector Current — Continuous	I_C	← 200 →			mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	360* 2.06		300* 1.71	mW mW/°C
Total Power Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2* 0.686* 6.86		1.8* 1.03 10.3	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A MM869B	2N4453	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	585	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	97.5	°C/W

*Indicates JEDEC Registered Data.



2N4453

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 26-03
TO-46

All JEDEC dimensions and notes apply

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N869A, 2N4453	$V_{CEO(sus)}$	18	–	–	Vdc
	MM869B		30	–	–	
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N869A, 2N4453	BV_{CES}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N869A	BV_{CBO}	25	–	–	Vdc
	MM869B		30	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	–	–	10	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N869A, MM869B	I_{CBO}	–	–	25	μAdc
Emitter Cutoff Current (V_{EB} = 4.5 Vdc, I_C = 0)	2N4453	I_{EBO}	–	–	10	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N869A, MM869B	I_B	–	–	10	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N869A, MM869B		30	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N869A, MM869B		40	–	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)	2N869A, MM869B		40	–	120	
	2N4453		40	–	–	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)	2N869A, MM869B		17	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N869A, MM869B		25	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A, MM869B		–	–	0.15	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		–	–	0.25	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A, MM869B		–	–	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A, MM869B		–	–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A, MM869B		0.78	–	0.98	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		0.8	–	1.1	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A, MM869B		0.85	–	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A, MM869B		–	–	1.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	400	–	–	MHz
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N4453	C_{eb}	–	–	6.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N4453	C_{cb}	–	–	6.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	2N869A, MM869B	C_{ob}	–	–	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 150 kHz)	2N869A, MM869B	C_{ib}	–	–	6.0	pF

SWITCHING CHARACTERISTICS (Figure 3)

Turn-On Time	I_C = 30 mAdc, I_{B1} = 1.5 mAdc	V_{CC} = 2.0 Vdc, 2N869A, MM869B	t_{on}	–	30	50	ns
Delay Time		V_{CC} = 3.0 Vdc, 2N4453	t_d	–	13	35	ns
Rise Time		V_{CC} = 3.0 Vdc, 2N4453	t_r	–	17	20	ns
Turn-Off Time	I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc	V_{CC} = 2.0 Vdc, 2N869A, MM869B	t_{off}	–	60	80	ns
Storage Time		V_{CC} = 3.0 Vdc, 2N4453	t_s	–	43	65	ns
Fall Time		V_{CC} = 3.0 Vdc, 2N4453	t_f	–	17	20	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON TIME

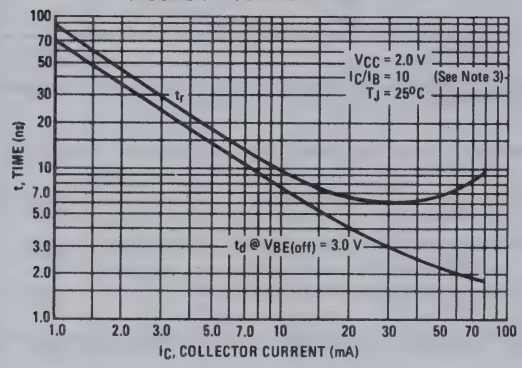


FIGURE 2 – TURN-OFF TIME

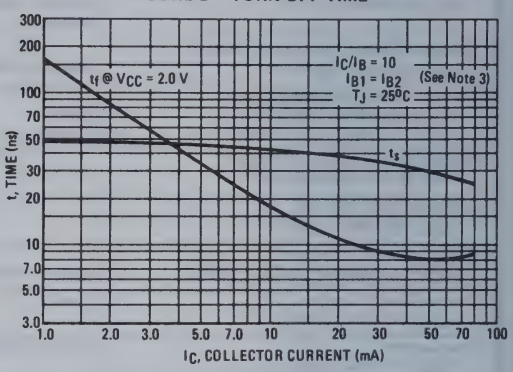


FIGURE 3 – SWITCHING TIME TEST CIRCUIT

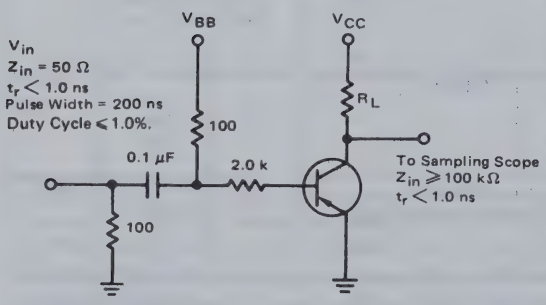


FIGURE 4 – CAPACITANCE

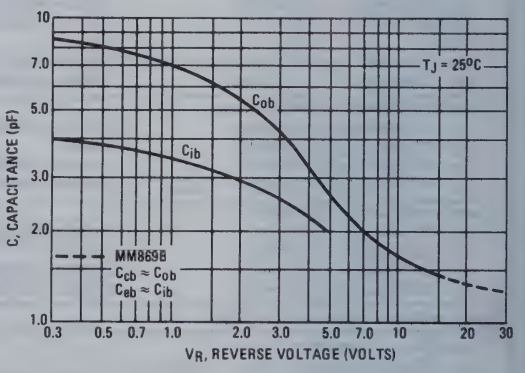


FIGURE 5 – SWITCHING TEST CIRCUIT VALUES

		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	I_{B1}(4) mA	I_{B2}(4) mA
t_{on}, t_r, t_d	2N869A, MM869B	-7.0	3.0	2.0	62	30	1.5	–
	2N4453	-7.0	3.0	3.0	91	30	1.5	–
t_{off}, t_s, t_f	2N869A, MM869B	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

(3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = 30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.

(4) I_{B1} = I_{B2} = 3.0 mA @ I_C/I_B = 10

FIGURE 6 – DC CURRENT GAIN

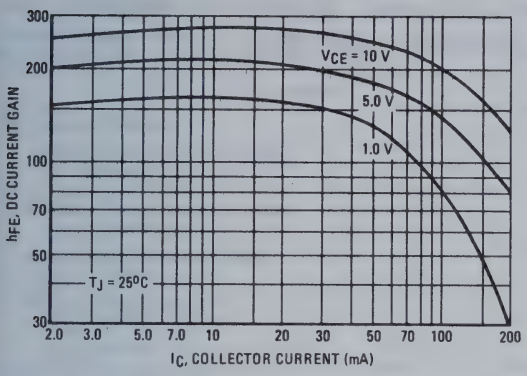


FIGURE 7 – "ON" VOLTAGES

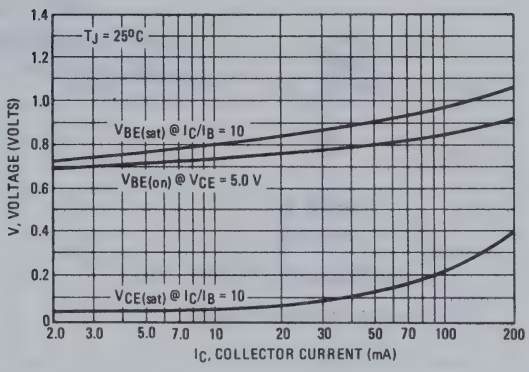
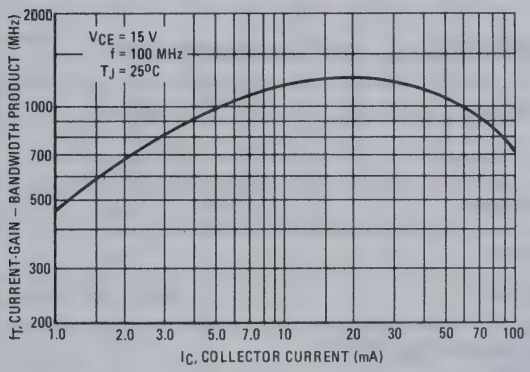


FIGURE 8 – CURRENT-GAIN – BANDWIDTH PRODUCT



MM1500, A (SILICON)
MM1501, A



NPN silicon RF power transistors designed for UHF amplifier, frequency multiplier, and oscillator applications.

CASE 23
(TO-107)
A parts Case, 24 (TO-102) stud
Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltagee	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	—	0.1	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			—	—	100	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM1500, A MM1501, A	f_T	— —	1500 1000	— —	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	3.2	5.0	pF
Collector-Base Time Constant (I_E = 100 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	MM1500, A MM1501, A	$r_b'C_c$	— —	7.0 10	— —	ps
FUNCTIONAL TEST						
Power Output, Figure 1 (V_{CB} = 20 Vdc, R_L = 50 ohms, f = 1500 MHz)	MM1500, A MM1501, A	P_{out}	250 150	— —	— —	mW

FIGURE 1 — POWER OUTPUT TEST CIRCUIT

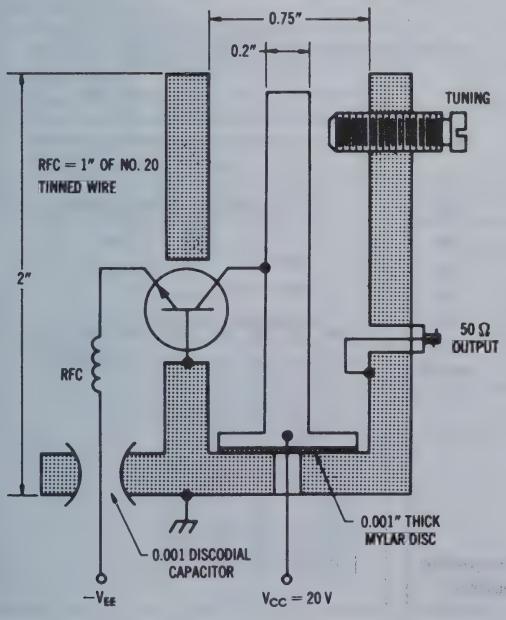
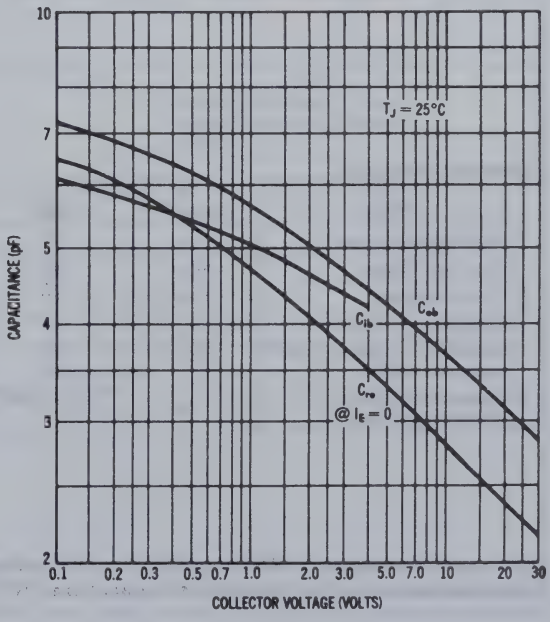


FIGURE 2 — CAPACITANCES



MM1553 (SILICON)

NPN SILICON RF POWER TRANSISTOR

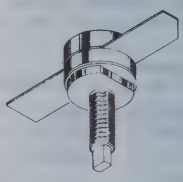
. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

- High Output Power Capability –
  90 Watts Peak Output for 13.5 Watts (Max) Input @ f = 150 MHz
- Balanced Emitter Construction to Assure Ruggedness and Resist Transistor Damage Caused by Load Mismatch
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

75 W – 150 MHz

RF POWER TRANSISTOR

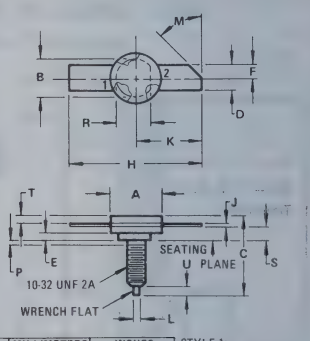
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C=50°C Derate above 50°C	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.45	12.95	0.490	0.510
B	10.41	10.92	0.410	0.430
C	21.21	21.46	0.835	0.845
D	8.51	8.76	0.335	0.345
E	1.78	2.03	0.070	0.080
F	4.19	4.45	0.165	0.175
H	22.86	23.62	0.900	0.930
J	0.10	0.15	0.004	0.006
K	11.43	11.81	0.450	0.465
L	1.65	1.91	0.065	0.075
M	40°	50°	40°	50°
P	–	1.27	–	0.050
R	9.78	10.03	0.385	0.395
S	4.11	4.42	0.162	0.174
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

STYLE 1:
PIN 1. BASE
2. COLLECTOR
STUD-EMITTER

CASE 145C-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	70	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	70	85	pF

FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CE} = 44 Vdc and not retuned for 22 Vdc Carrier Power Test)

Power Input (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	11	13.5	Watts
Power Output CW (Carrier Power) (P_{in} = 6.0 W, V_{CE} = 22 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CE} = 44 Vdc)	P_{out}	25	28	–	Watts
Power Output CW (V_{CE} = 44 Vdc, f = 150 MHz, Saturated CW Output Power)	P_{out}	75	–	–	Watts
Collector Efficiency (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	η	50	–	–	%
Load Mismatch (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated. Device Subjected to All Conditions of Load Mismatch from Short-Circuit to Open Circuit)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

FIGURE 1 – POWER OUTPUT versus POWER INPUT

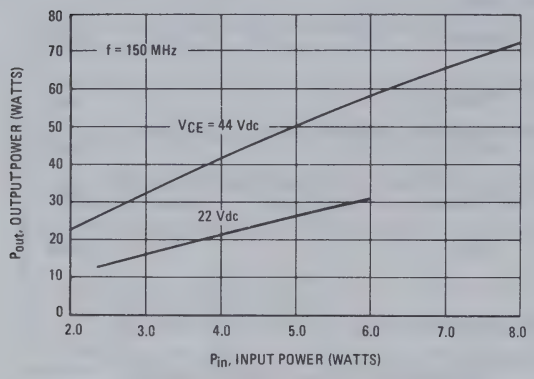


FIGURE 2 – POWER OUTPUT versus POWER INPUT

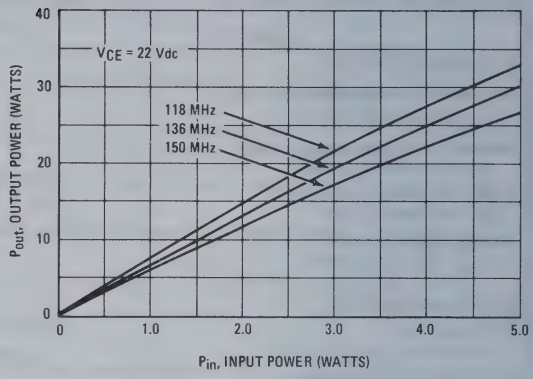


FIGURE 3 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

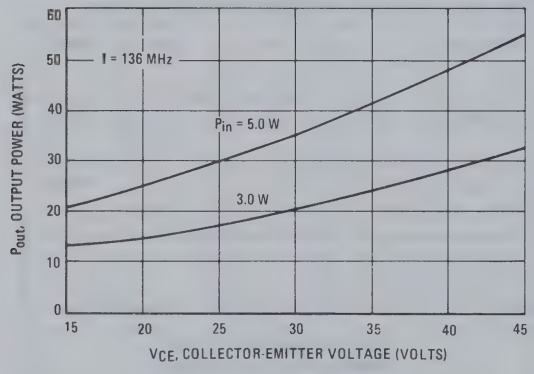


FIGURE 4 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

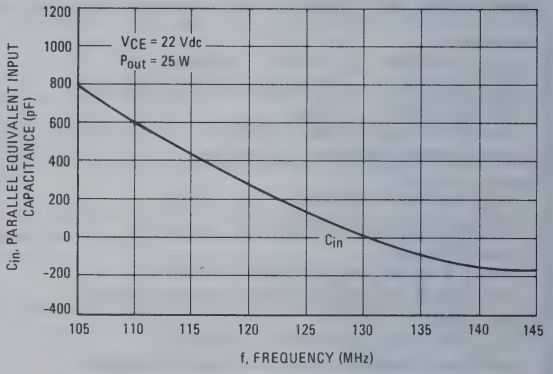


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

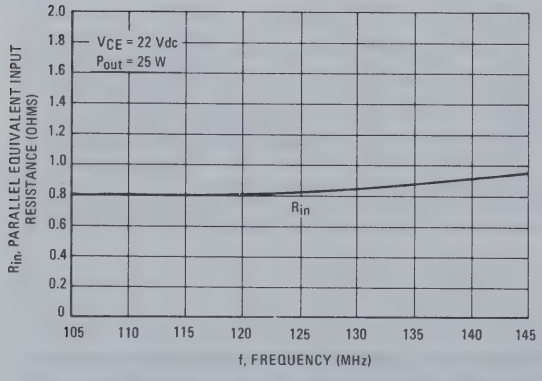


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

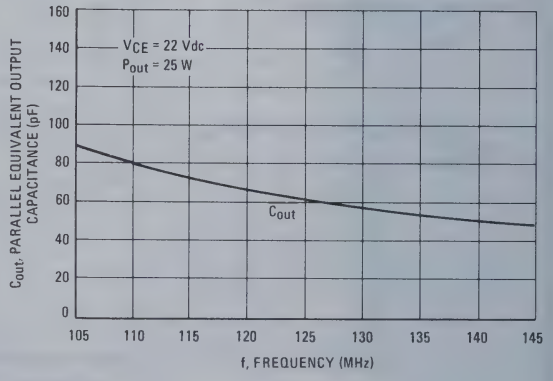


FIGURE 7 – SAFE-OPERATING AREA

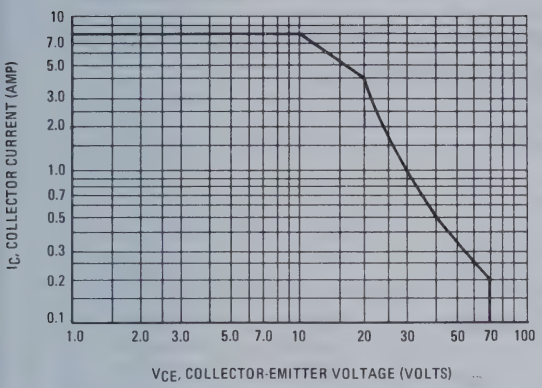


FIGURE 8 – POWER-TEMPERATURE DERATING CURVE

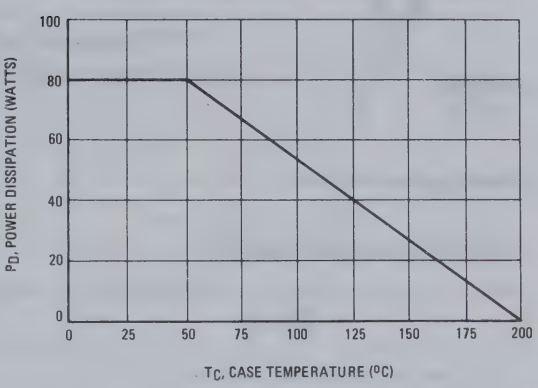
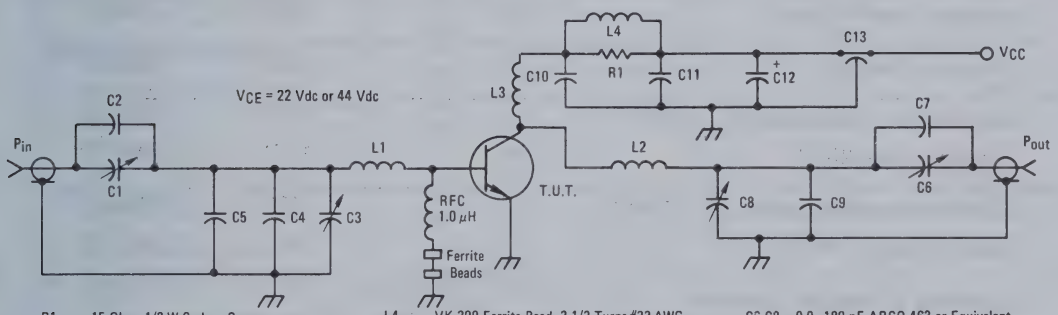
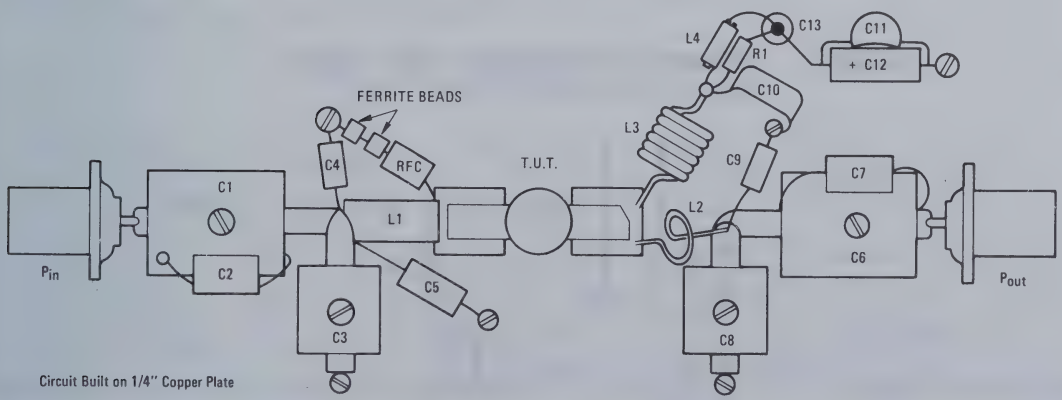


FIGURE 9 – 150 MHz TEST CIRCUIT



R1	15 Ohm, 1/2 W Carbon Comp.	L4	VK 200 Ferrite Bead, 2-1/2 Turns #22 AWG	C6,C8	9.0–180 pF ARCO 463 or Equivalent
L1	3/4" x 1/4" x 0.040" Copper Strap	C1	1.5–15 pF ARCO 460 or Equivalent	C7	4.7 pF Glass
L2	1 Turn #16 AWG Tinned Wire, 1/4" I.D. Closewound (3/4" Total Length)	C2	6.8 pF Glass	C10	2000 pF Mica
		C3	2.7–30 pF ARCO 461 or Equivalent	C11	0.01 μF Ceramic
L3	10 Turns #18 AWG Coated Wire, 5/8" I.D. Closewound (1" Total Length)	C4	12 pF Glass	C12	5.0 μF, 50 V Foil Electrolytic
		C5,C9	22 pF Glass	C13	1200 pF Ceramic Feed-Thru

FIGURE 10 – 150 MHz TEST CIRCUIT LAYOUT



MM1748 (SILICON)



CASE 27
(TO-52)

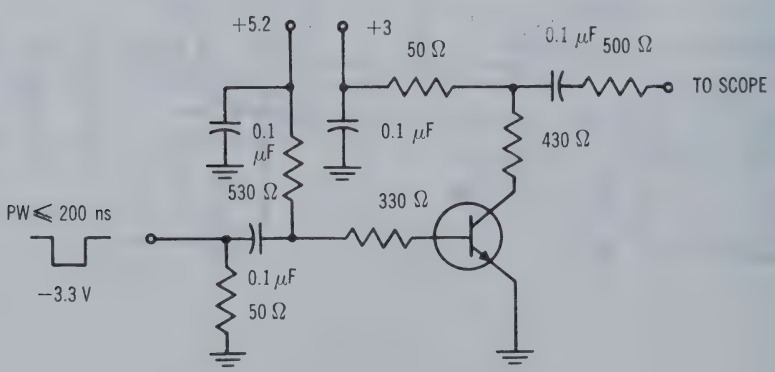
NPN silicon annular transistor designed for ultra-high speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation $T_A = 25^oC$ Derate above 25^oC	P_D	300 1.71	mWatts $mW/^oC$
Total Device Dissipation $T_C = 100^oC$ Derate above 100^oC	P_D	500 2.0	mWatts $mW/^oC$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

FIGURE 1 — STORAGE TIME CONSTANT TEST CIRCUIT

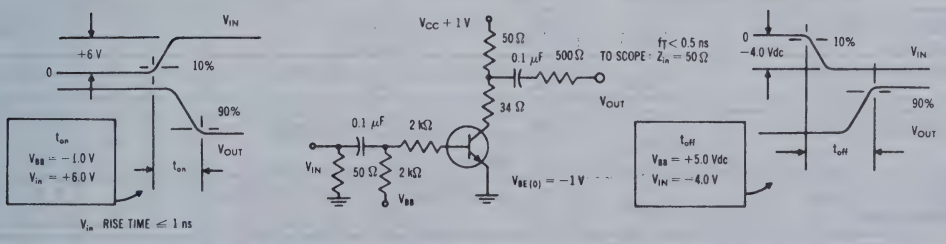


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	6.0	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	-	0.002	0.05	μAdc
(V_{CB} = 5 Vdc, I_E = 0, T_A = 125°C)		-	0.5	5.0	
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	20	-	120	-
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)		10	-	-	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)		15	-	-	
Collector-Emitter Saturation Voltage (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{CE(sat)}$	-	0.2	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{BE(sat)}$	0.70	-	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 MHz)	f_T	600	-	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0)	C_{ob}	-	-	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)	C_{ib}	-	-	2.0	pF
Turn-On Time, Figure 2 (V_{CC} = 1 Vdc, V_{EB} (off) = 1 Vdc, I_C = 10 mAdc, I_{B1} = 2 mAdc, I_{B2} = 1.0 mA)	t_{on}	-	8.0	15	ns
Turn-Off Time, Figure 2 (V_{CC} = 1 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1 mAdc)	t_{off}	-	6.0	15	ns
Storage Time, Figure 1 (I_C = 5 mAdc, I_{B1} = I_{B2} = 5 mAdc)	t_s	-	-	6.0	ns

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

FIGURE 2 — TURN-ON & TURN-OFF TIME TEST CIRCUIT



MM1803 (SILICON)

For Specifications, See 2N3137, Volume I.

MM1941 (SILICON)



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency power oscillator, multiplier and driver applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Base Current	I_B	30	mAdc
Collector Current	I_C	200	mAdc
Input Power	P_{in}	100	mW
Output Power	P_{out}	250	mW
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D*	600 4.0	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	300 2.0	mW mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*See Safe Area Curve

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

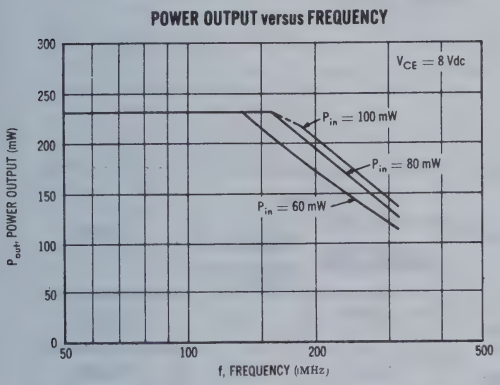
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter (1) Sustain Voltage	$V_{CES(sus)}$	I_C = 15 mA, R_{BE} = 0	30	40	-	Vdc
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	30	40	-	Vdc
Collector Emitter-Open Base Sustain Voltage (1)	$BV_{CEO(sus)}$	I_C = 15 mA, I_B = 0	20	-	-	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_C = 100°C	- -	0.01 -	0.1 25	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	-	0.1	10	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	25	50	-	-
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 100 mc	6.0	8.0	-	-
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz	-	-	2.5	pF
Power Output	P_{out}	P_{in} = 20 mW max, f = 175 MHz	100	-	-	mW
Power Gain	G_e	V_{CC} = 13.6 Vdc, $I_{C(max)}$ = 25 mA	7.0	9.0	-	dB

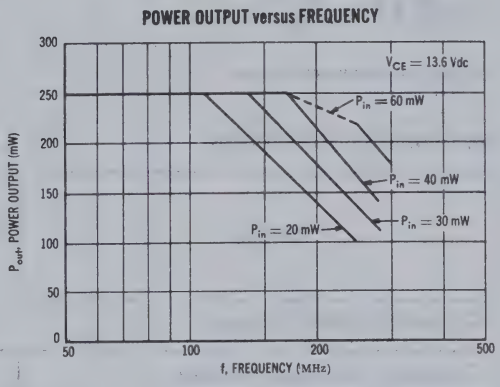
(1) Pulse Test: PW = 100 μs; DC = 2%

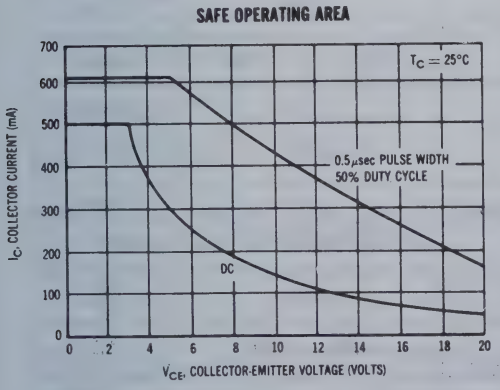
ELECTRICAL CHARACTERISTICS (continued)

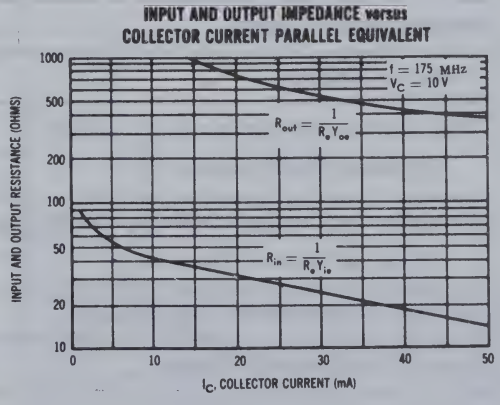
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Output (Oscillator)	P_{out}	f = 80 MHz, V_{CC} = 13.6 Vdc, $I_{C(typ)}$ = 20 mAdc	-	50	-	mW
Power Gain (Multiplier)	G_e	f_{in} = 80 MHz, f_{out} = 240 MHz, V_{CC} = 13.6 Vdc, P_{out} ≈ 30 mW, $I_{C(typ)}$ = 25 mAdc	-	3.0	-	dB

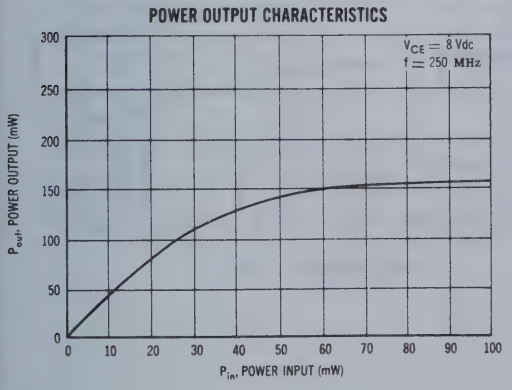
*Pulse Test: PW = 100 μs; DC = 2%

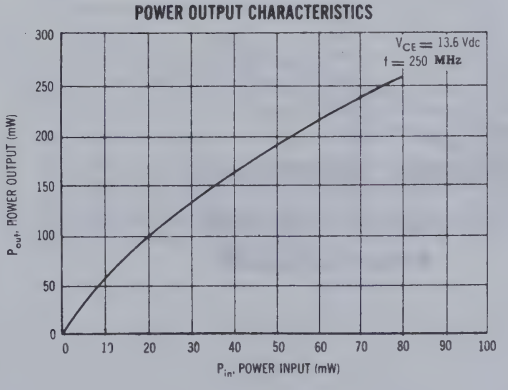












MM2258 (SILICON)
MM2259
MM2260



CASE 31
(TO-5)

Collector connected to case

NPN silicon transistors designed for video output circuitry in transistorized television receivers.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MM2258	MM2259 MM2260	
Collector-Base Voltage	V_{CB}	120	175	Vdc
Collector-Emitter Voltage	V_{CEO}	120	175	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5.0 28.6		Watt mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE

$\theta_{JA(air)} = 175°C/W$
$\theta_{JC(case)} = 35°C/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	0.050 50	μAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)		I_{EBO}	—	—	25	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MM2258 MM2259, MM2260	BV_{CBO}	120 175	— —	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM2258 MM2259, MM2260	BV_{CEO}*	120 175	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	MM2259 MM2258, MM2260 MM2259 MM2258, MM2260 MM2259 MM2258, MM2260	h_{FE}	25 50 35 50 35 50	— — — — — —	— — — — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MM2258 MM2259, MM2260	C_{ob}	— —	— —	9.0 8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	80	pF
Feedback (Miller) Capacitance (V_{CB} = 25 Vdc, I_C = 10 mAdc)	MM2258 MM2259, MM2260	C_{cb}	— —	4.2 3.0	5.0 4.5	pF
Small Signal Current Gain (V_{CE} = 25 Vdc, I_C = 20 mAdc, f = 100 MHz)		$\|h_{fe}\|$	1.5	—	—	—

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

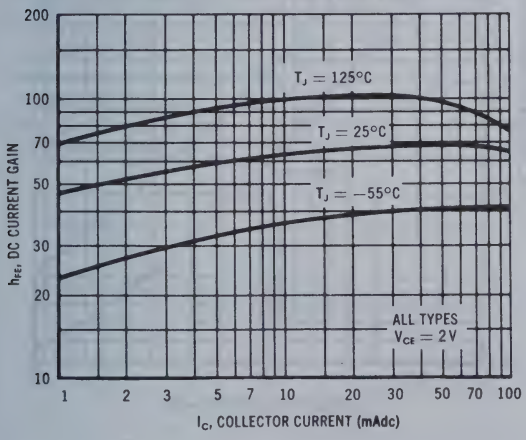
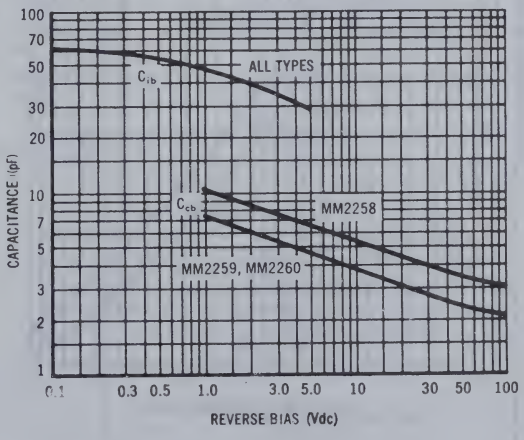


FIGURE 2 — JUNCTION CAPACITANCE VARIATIONS



SMALL SIGNAL h PARAMETER CHARACTERISTICS
(V_{CE} = 10 V, T_A = 25°C, f = 1 kHz)

FIGURE 3 — CURRENT GAIN

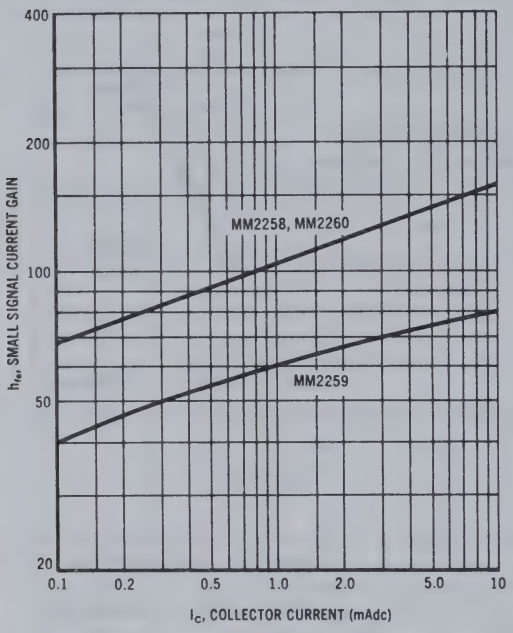


FIGURE 4 — OUTPUT ADMITTANCE

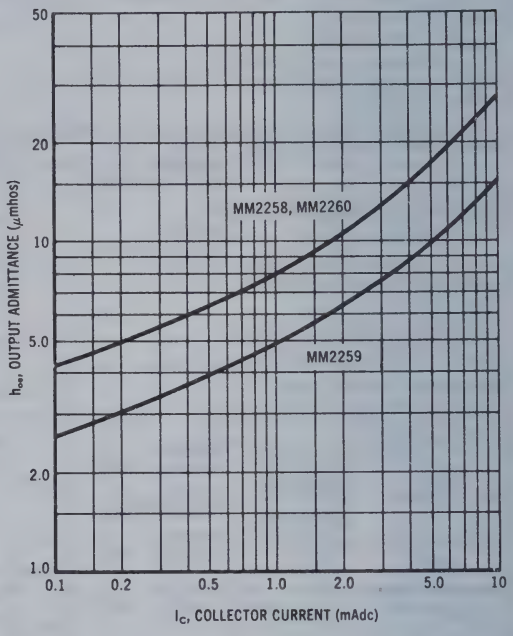


FIGURE 5 — INPUT IMPEDANCE

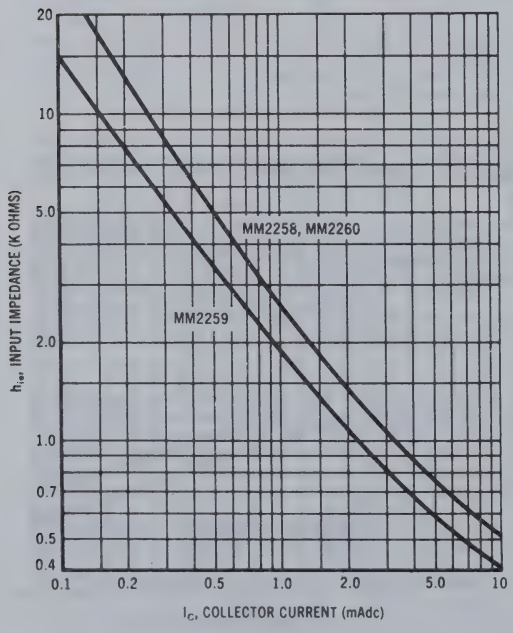
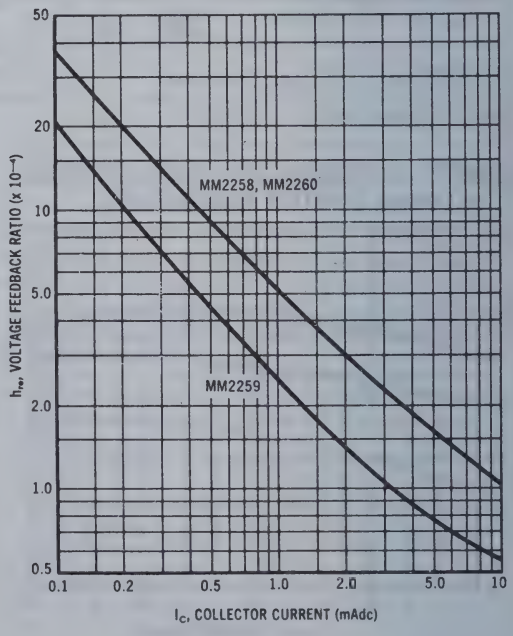


FIGURE 6 — VOLTAGE FEEDBACK RATIO



MM2894A (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for low-power, high-speed saturated switching applications in industrial service.

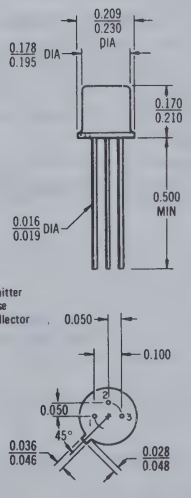
- Low Output Capacitance —
  C_{ob} = 4.5 pF (Max) @ V_{CB} = 5.0 Vdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.19 Vdc (Max) @ I_C = 30 mAdc
- High Current-Gain — Bandwidth Product —
  f_T = 800 MHz (Min) @ I_C = 30 mAdc
- Turn-Off Time —
  t_{off} = 35 ns (Max) @ $I_C \approx$ 30 mAdc

PNP SILICON SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C



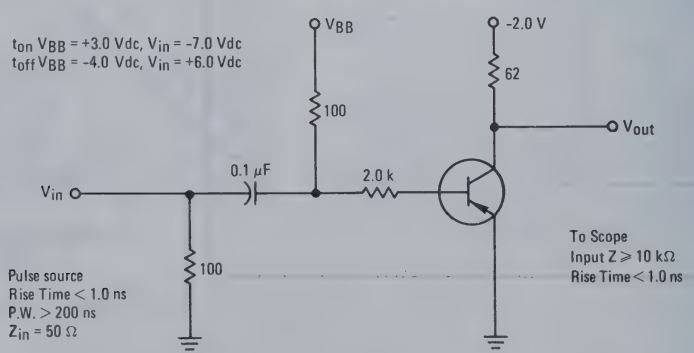
Collector Connected to Case
CASE 22(1)
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0)	I_{CES}	–	50	nAdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	–	10	μAdc
Base Current (V_{CE} = 10 Vdc, V_{BE} = 0)	I_B	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)		20	–	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	–	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		40	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C		20	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		30	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	0.13	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		–	0.19	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.45	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.75	0.92	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		0.80	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)		0.90	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	800	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	6.0	pF
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time (V_{CC} = 2.0 Vdc, $I_C \approx$30 mAdc, $I_{B1} \approx$1.5 mAdc)	t_{on}	–	60	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, $I_C \approx$30 mAdc, $I_{B1} = I_{B2} \approx$1.5 mAdc)	t_{off}	–	35	ns

(1) Pulse Test: Pulse Width = 300 μs Duty Cycle = 1.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



MM3000 thru MM3003 (SILICON)



NPN silicon epitaxial transistors designed for general-purpose, high-voltage applications.

CASE 79
(TO-39)

MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	5.0				Vdc
Collector Current	I_C	200	200	50	50	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	1.0				Watt
Derate above 25°C		5.71				mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	5.0				Watts
Derate above 25°C		28.6				mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MM3000	BV_{CEO}	100		Vdc
	MM3000		100	-	
	MM3001		150	-	
	MM3002		200	-	
	MM3003		250	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	MM3000		-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	MM3001		-	1.0	
(V_{CB} = 100 Vdc, I_E = 0)	MM3002, MM3003		-	5.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	-	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM3000, MM3001	C_{ob}	-	7.0	pF
	MM3002, MM3003		-	15	

MM3005 (SILICON)
MM3006
MM3007

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage audio driver amplifiers and general-purpose switching and oscillator applications.

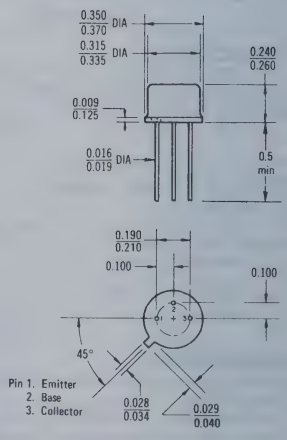
- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 100 Vdc (Min) @ I_C = 10 mAdc (MM3007)
- Low Output Capacitance –
  C_{ob} = 15 pF (Max) @ V_{CB} = 10 Vdc
- Excellent Gain Linearity – 1.0 to 250 mAdc
- Complements to PNP MM5005, MM5006, MM5007

NPN SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3006	MM3007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	2.5			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71			Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 45.6			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200			°C



CASE 79 (1)
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	MM3005		60	–	
	MM3006		80	–	
	MM3007		100	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	MM3005		80	–	
	MM3006		100	–	
	MM3007		120	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MM3005		–	100	
(V_{CB} = 80 Vdc, I_E = 0)	MM3006		–	100	
(V_{CB} = 100 Vdc, I_E = 0)	MM3007		–	100	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	All Types		40	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	MM3005		50	250	
(I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	MM3006		50	250	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	MM3007		50	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.35	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.60	0.75	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	15	pF

MM3008 (SILICON)
MM3009



High-voltage NPN silicon transistors designed for video output circuitry in transistorized television receivers.

CASE 79
(TO-39)

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	400		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM3008 MM3009	BV_{CEO}*	120 180	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc I_C = 0)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	 MM3008 MM3009	I_{CBO}	 - -	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}		0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30 40 30	- - -	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	-	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	20	pF

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — CURRENT GAIN

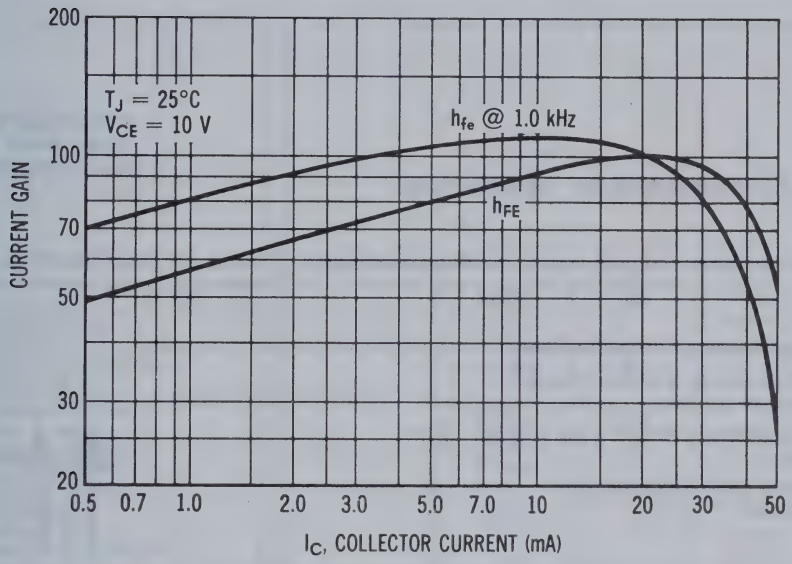
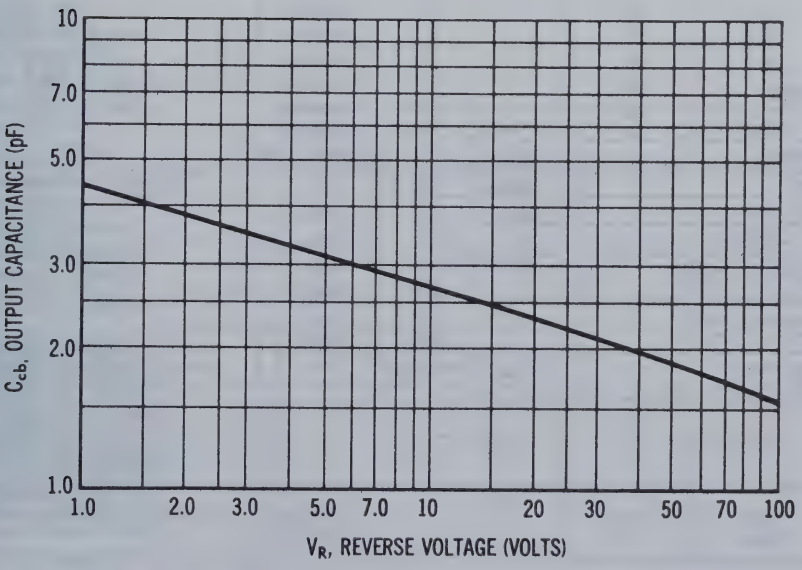


FIGURE 2 — CAPACITANCE



MM3019, MM3020 (SILICON)

NPN SILICON ANNULAR TRANSISTORS

. . . designed for medium current, medium power amplifier applications.

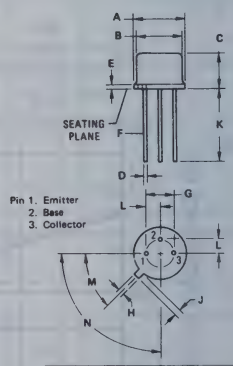
- Current Gain Specified — 100 μA to 1.0 Adc
- High Collector-Emitter Breakdown Voltage
  BV_{CEO} = 80 Vdc (Min)
- Similar to 2N3019 and 2N3020 in easy to handle TO-39 Packages
- High Collector Current — Continuous
  I_C = 1.0 Adc

NPN SILICON AMPLIFIER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CBO}	140	Vdc
Emitter-Base Voltage	V_{EBO}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.015	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0) (1)		BV_{CEO}	80	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 90 Vdc, I_E = 0)			–	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)			–	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MM3019		50	–	
	MM3020		30	100	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MM3019		90	–	
	MM3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MM3019		100	300	
	MM3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = -55°C)	MM3019		40	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MM3019		50	–	
	MM3020		30	100	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	MM3019, MM3020		15	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.2	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain – Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	80	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	60	pF
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 mAc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	MM3019		80	400	
	MM3020		30	200	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

MM3053 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for medium current, medium power amplifier and switching applications.

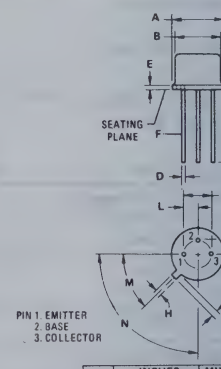
- High Collector-Emitter Breakdown Voltage
  BV_{CEO} = 50 Vdc (Min)
- Similar to 2N3053 in an easy to handle TO-39 Package
- High Collector Current — Continuous
  I_C = 1.0 Adc

NPN SILICON
SWITCHING AND AMPLIFIER
TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.72	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.015	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.026	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

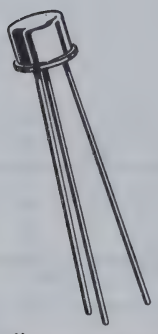
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	BV_{CBO}	80	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)	h_{FE}	 35 40	 – 300	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	80	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

MM3726 (SILICON)



Collector connected to case

CASE 31
(TO-5)

PNP silicon annular transistor designed for medium-current, high-speed saturated switching and core driver applications, and for complementary circuitry with NPN type MM3725.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	—	BV_{CEO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	—	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	—	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2 Vdc) (I_C = 1 Adc, V_{CE} = 5 Vdc)	9	h_{FE}	30 15	120 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	10, 11	$V_{CE(sat)}$	— —	0.6 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	11	$V_{BE(sat)}$	0.8 —	1.1 1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	—	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	3	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	3	C_{eb}	—	80	pF
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	1, 5, 6	t_{on}	—	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	2, 7, 8	t_{off}	—	90	ns
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 1 Adc, I_{B1} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	1, 5, 6	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	2, 7, 8	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

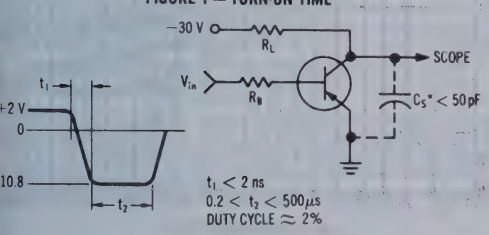
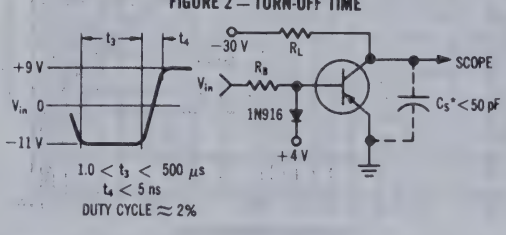


FIGURE 2 — TURN-OFF TIME



*TOTAL SHUNT CAPACITANCE OF TEST JIG, CONNECTORS, AND OSCILLOSCOPE.

TRANSIENT CHARACTERISTICS

— 25°C --- 150°C

FIGURE 3 — CAPACITANCES

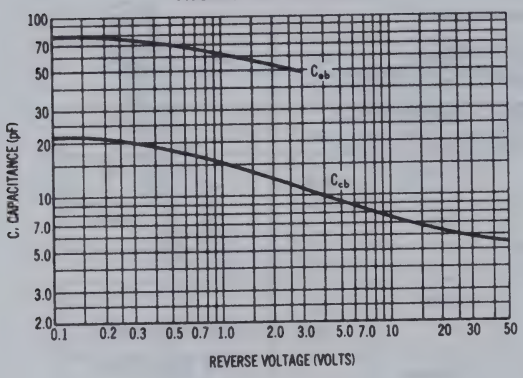


FIGURE 4 — CHARGE DATA

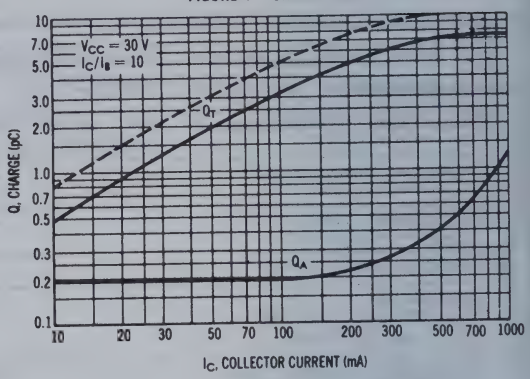


FIGURE 5 — TURN-ON TIME

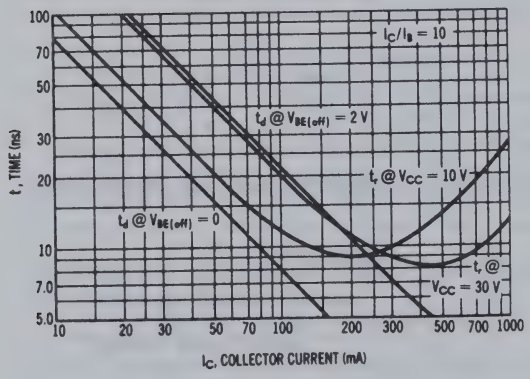


FIGURE 6 — RISE TIME

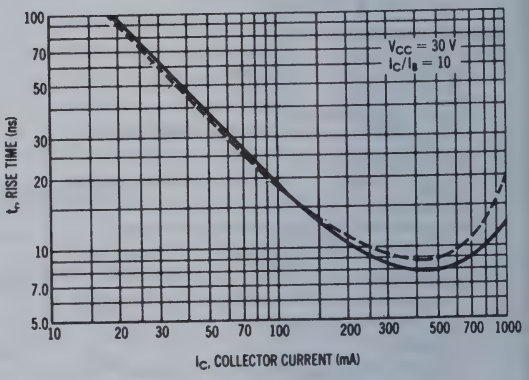


FIGURE 7 — STORAGE TIME

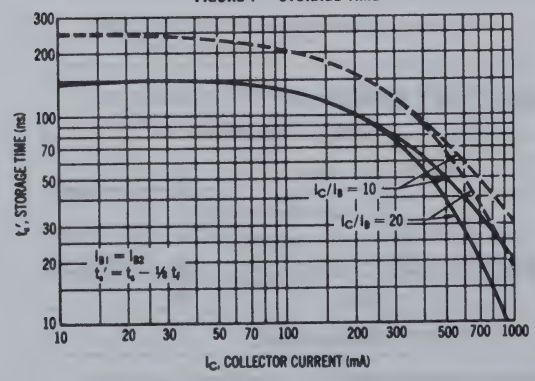
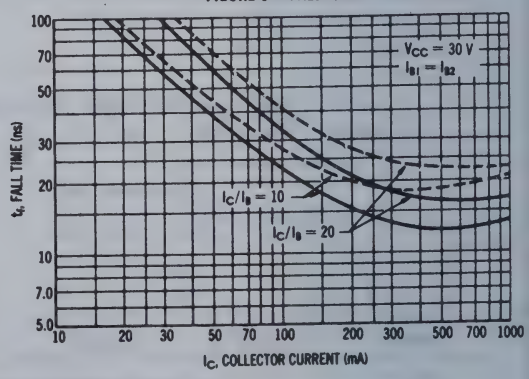


FIGURE 8 — FALL TIME



STATIC CHARACTERISTICS

FIGURE 9 — CURRENT GAIN

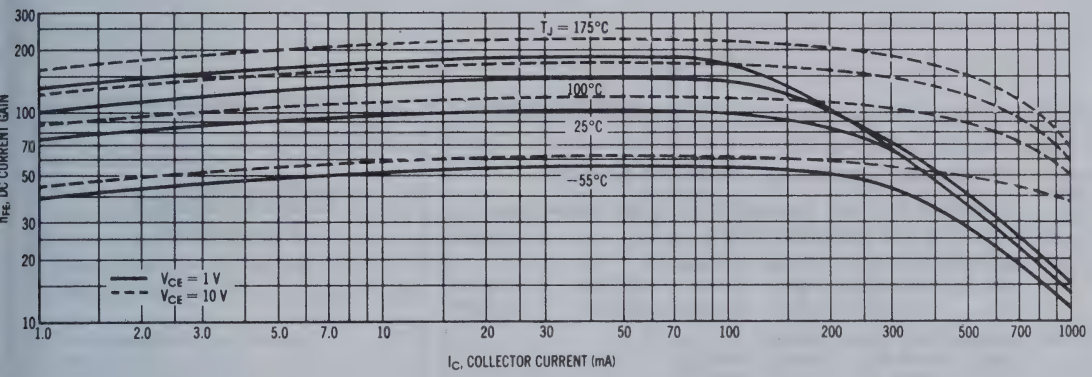


FIGURE 10 — SATURATION REGION

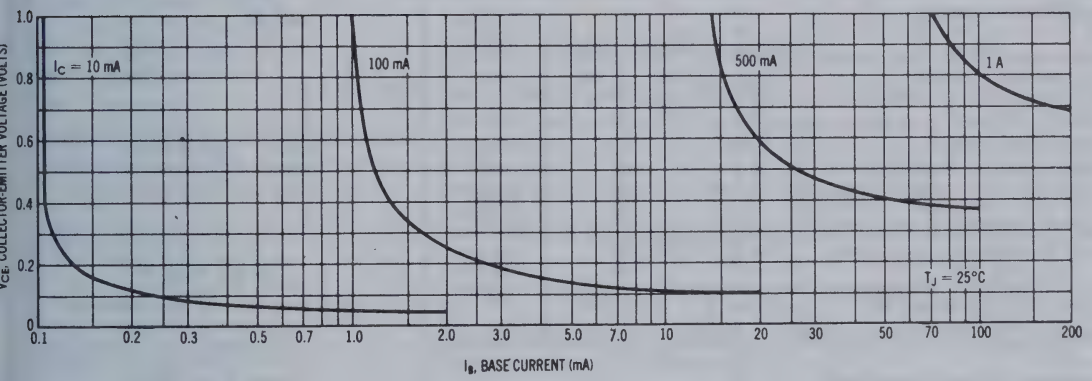


FIGURE 11 — "ON" VOLTAGES

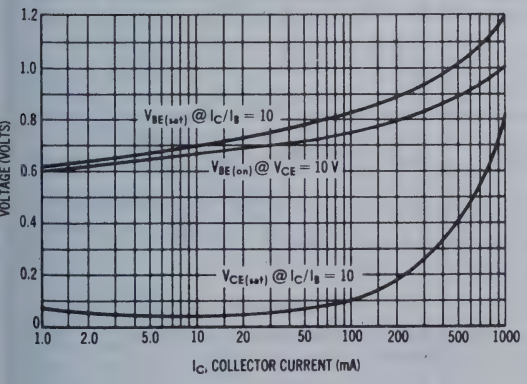
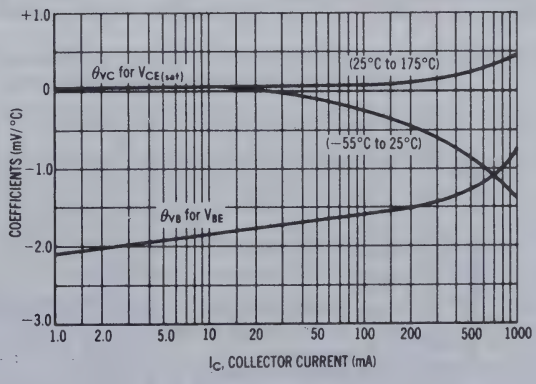


FIGURE 12 — TEMPERATURE COEFFICIENTS



MM3736, MM3737 (SILICON)

NPN SILICON ANNULAR MEMORY DRIVER

. . . designed for 1 Ampere, high-speed switching applications such as ferrite core memory and hammer drivers.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc – MM3736
  = 50 Vdc (Min) @ I_C = 10 mAdc – MM3737
- Guaranteed High DC Current Gain –
  h_{FE} = 30-120 @ I_C = 1.0 Adc – MM3736
  = 20-80 @ I_C = 1.0 Adc – MM3737
- Guaranteed Fast Switching Times @ I_C = 1.0 Adc –
  t_{on} = 45 ns (Max) t_{off} = 65 ns (Max)

NPN SILICON MEMORY DRIVER TRANSISTOR



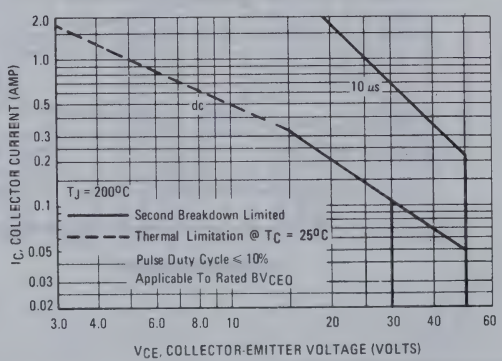
*MAXIMUM RATINGS

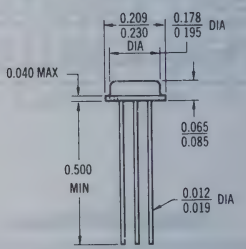
Rating	Symbol	MM3736	MM3737	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	50	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.4		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

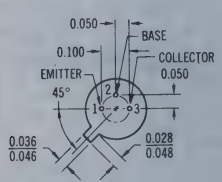
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Air	θ_{JA}	0.35	°C/mW
Thermal Resistance, Junction to Case	θ_{JC}	0.088	°C/mW

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA







All JEDEC dimensions and notes apply

Collector Connected to Case

CASE 26
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM3736	BV_{CEO}	30	–	Vdc
	MM3737		50	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MM3736	BV_{CBO}	50	–	Vdc
	MM3737		75	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc)	MM3736		–	0.5	
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	MM3736		–	50	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc)	MM3737		–	0.5	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	MM3737		–	50	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc)	MM3736		–	0.5	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc)	MM3737		–	0.5	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			35	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	–	
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)	MM3736		30	120	
	MM3737		20	80	
Collector Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.2	
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.9	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)			–	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.2	
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.9	1.4	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f - 100 MHz)		f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	9.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	t_d	–	8.0	ns
Rise Time	I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_r	–	40	ns
Turn-On Time		t_{on}	–	45	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc,	t_s	–	45	ns
Fall Time	I_{B1} = I_{B2} = 100 mAdc)	t_f	–	30	ns
Turn-Off Time		t_{off}	–	65	ns
Total Control Charge (I_C = 1.0 Adc, I_B = 100 mAdc, V_{CC} = 30 Vdc)		Q_T	–	10	nC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

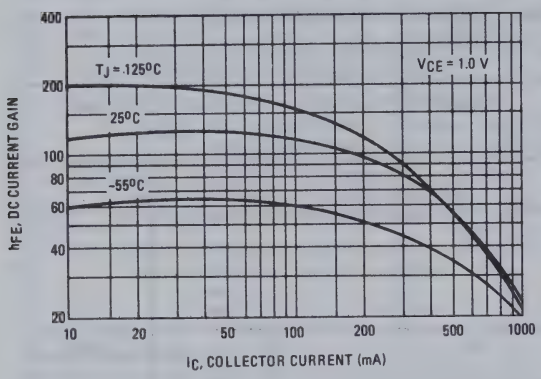


FIGURE 3 – "ON" VOLTAGES

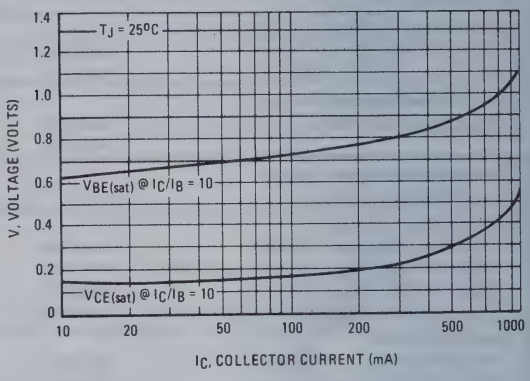


FIGURE 4 – COLLECTOR SATURATION REGION

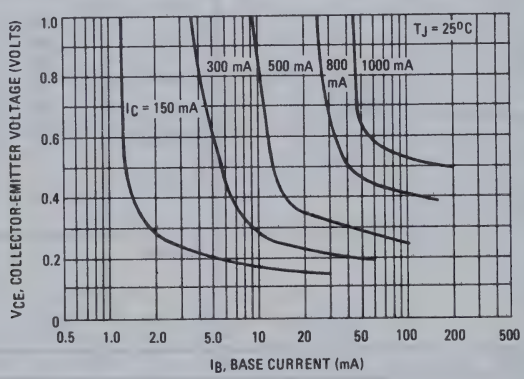


FIGURE 5 – TEMPERATURE COEFFICIENTS

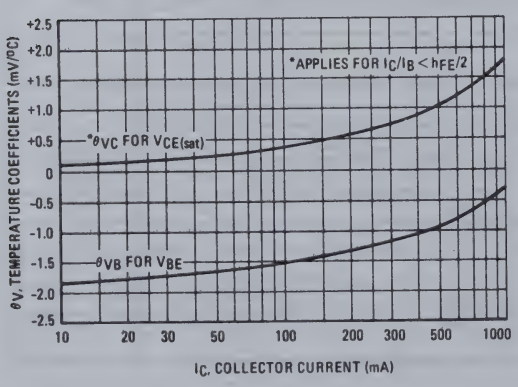
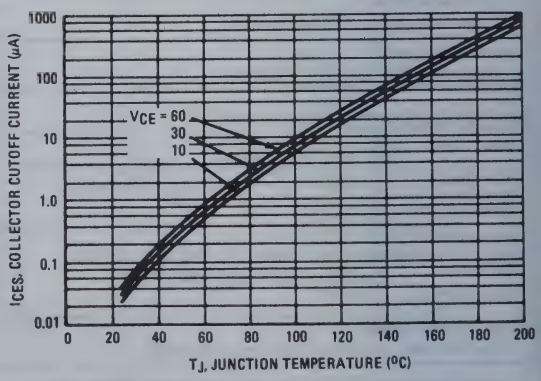


FIGURE 6 – COLLECTOR CUTOFF CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 7 – CURRENT GAIN – BANDWIDTH PRODUCTS

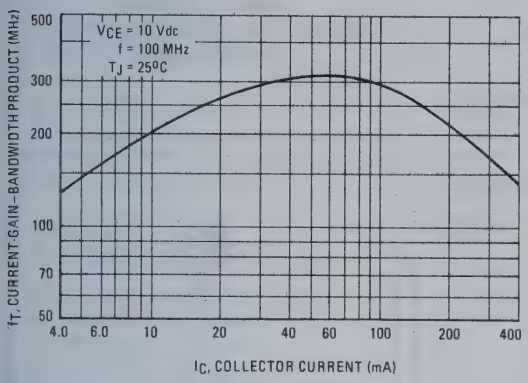


FIGURE 8 – CAPACITANCE

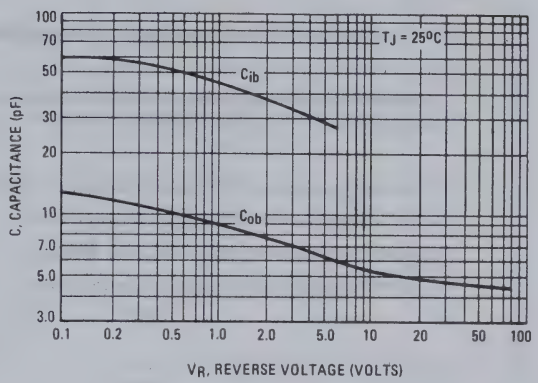


FIGURE 9 – TURN-ON TIME

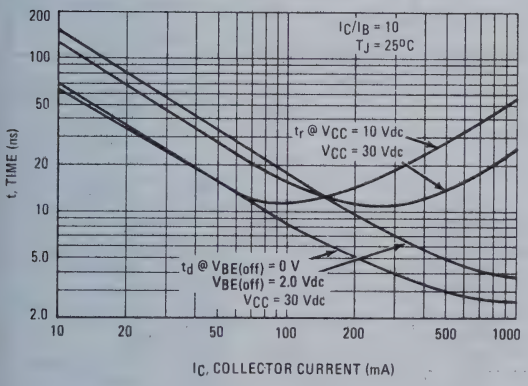


FIGURE 10 – TURN-OFF TIME

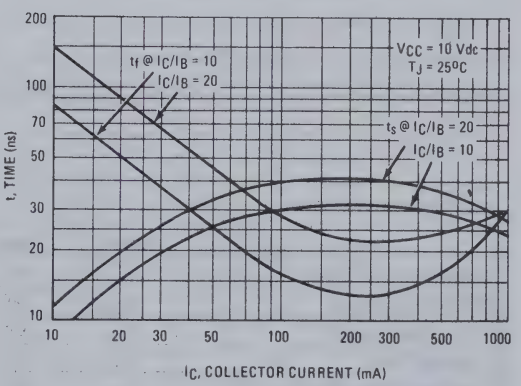
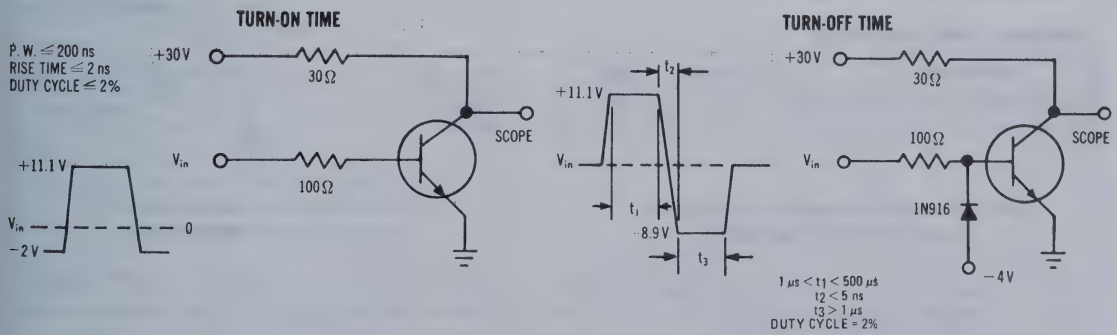


FIGURE 11 – SWITCHING TIME TEST CIRCUIT



MM3903 (SILICON)
MM3904

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3903 and 2N3904.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings — BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

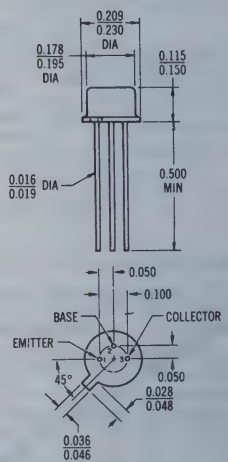


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW



CASE 27
(TO-52)

MM3903, MM3904 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		-	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		-	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{BL}	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904	15	h_{FE}	20 40	- -	-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			35 70	- -	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			30 60	- -	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			10 15	- -	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		16, 17	$V_{CE(sat)}$	-	0.2	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.3	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		17	$V_{BE(sat)}$	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3903 MM3904	-	f_T	250 300	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	13	h_{ie}	0.5 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	14	h_{re}	0.1×10^{-4} 0.5×10^{-4}	5×10^{-4} 8×10^{-4}	-
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	11	h_{fe}	50 100	200 400	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		12	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	MM3903 MM3904	9, 10	NF	- -	6.0 5.0	dB
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3903 MM3904	2, 7	t_s	- -	175 200	ns
Fall Time		2, 8	t_f	-	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

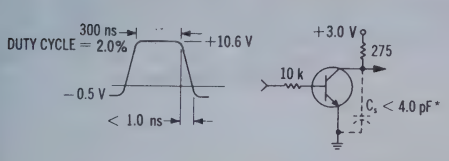
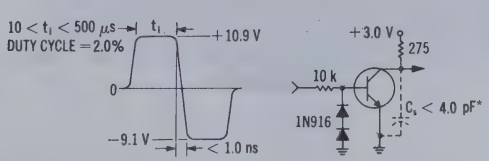


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

——— $T_J = 25^oC$ ----- $T_J = 125^oC$

FIGURE 3 – CAPACITANCE

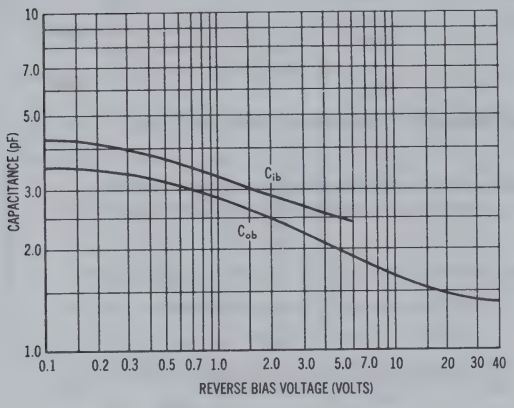


FIGURE 4 – CHARGE DATA

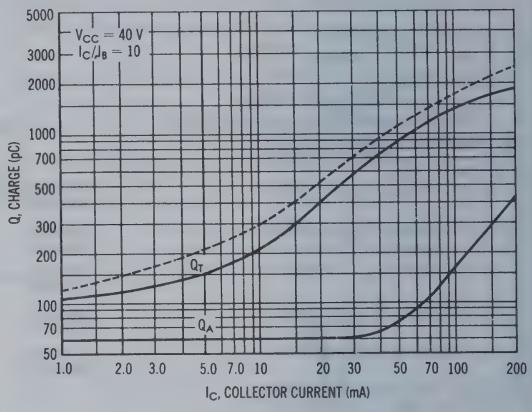


FIGURE 5 – TURN-ON TIME

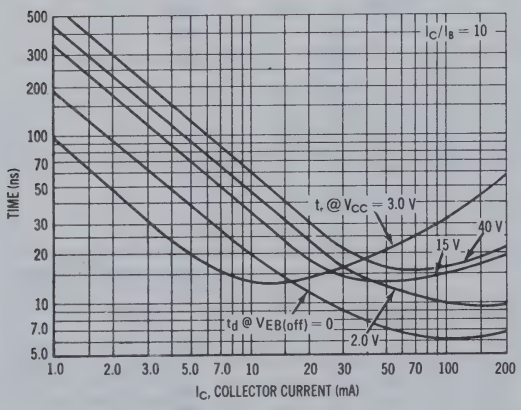


FIGURE 6 – RISE TIME

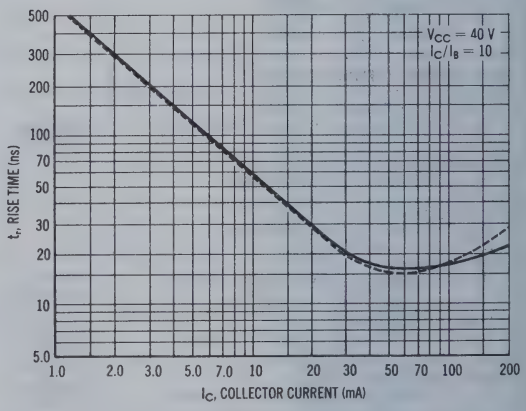


FIGURE 7 – STORAGE TIME

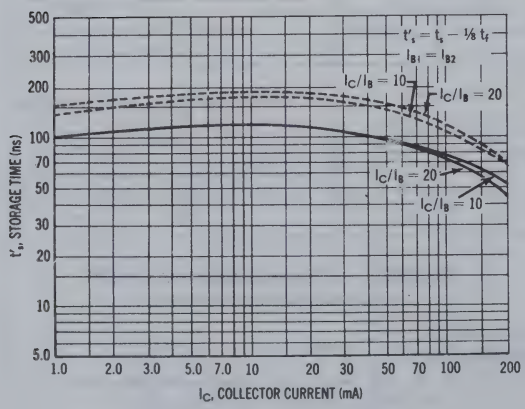
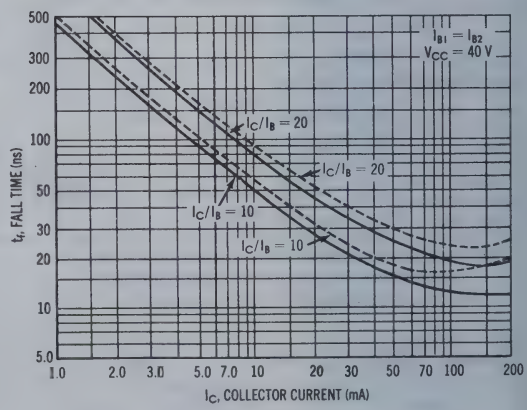


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

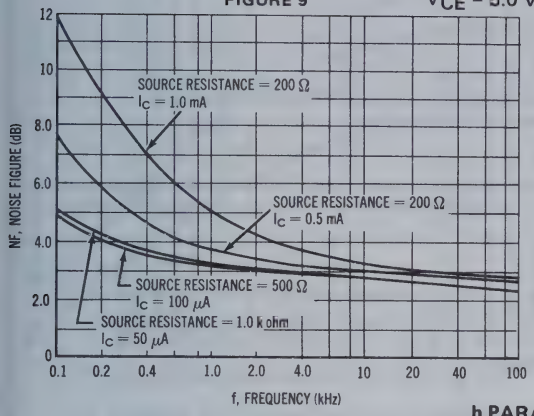
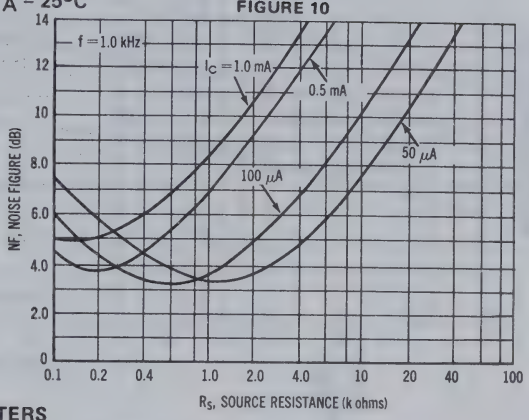


FIGURE 10



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 11 – CURRENT GAIN

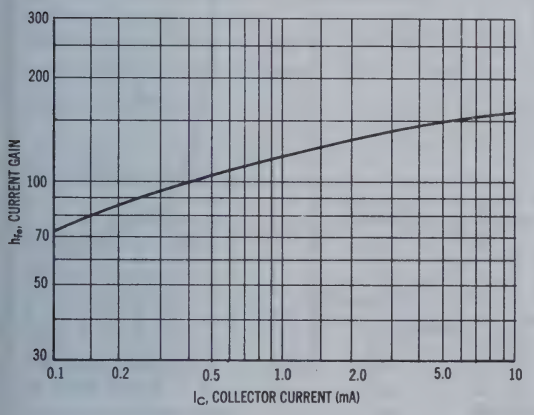


FIGURE 12 – OUTPUT ADMITTANCE

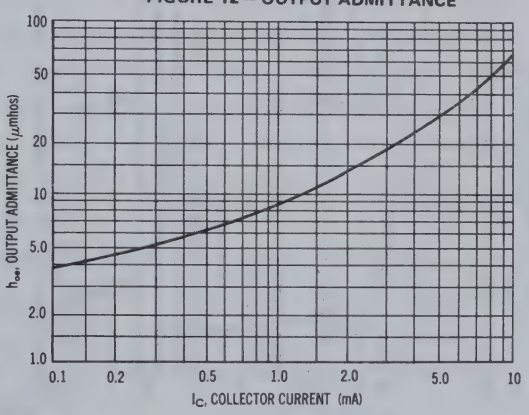


FIGURE 13 – INPUT IMPEDANCE

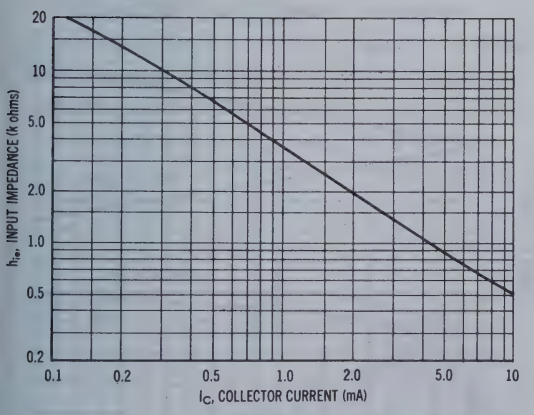
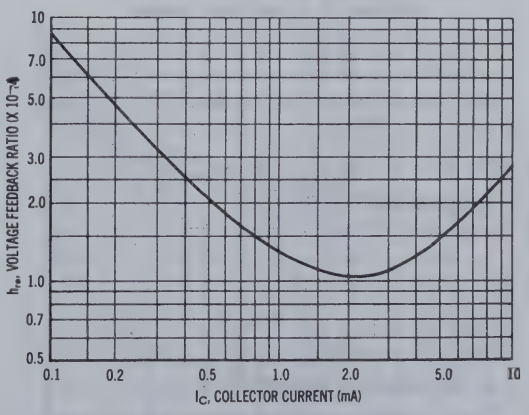


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – NORMALIZED CURRENT GAIN

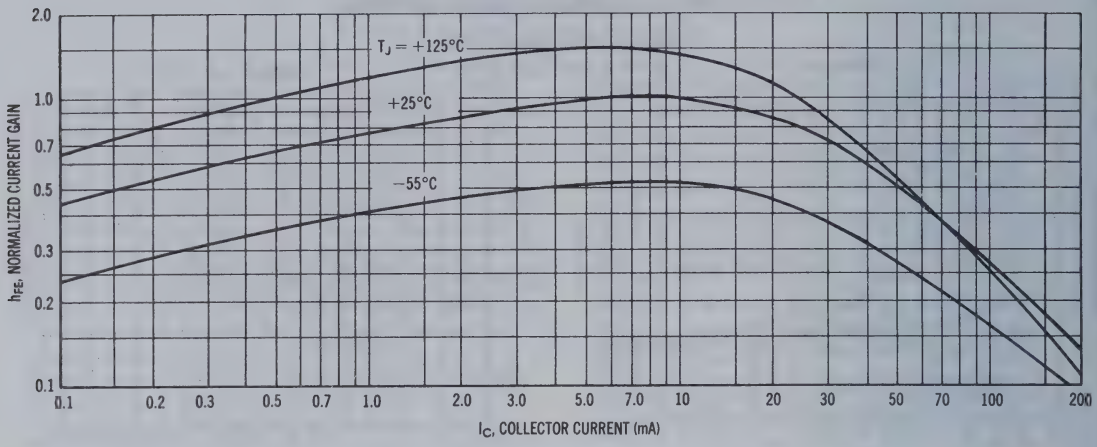


FIGURE 16 – COLLECTOR SATURATION REGION

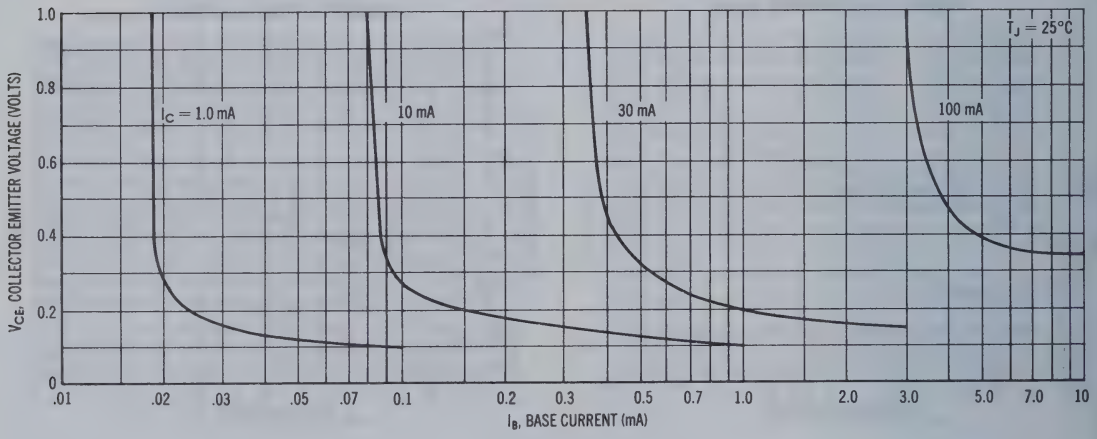


FIGURE 17 – "ON" VOLTAGES

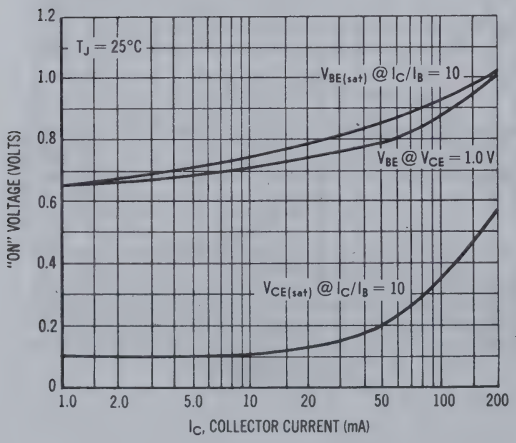
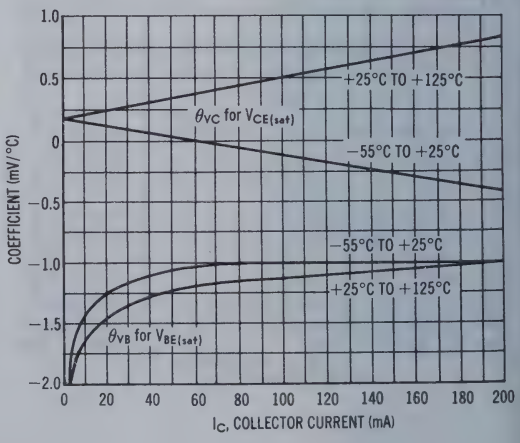


FIGURE 18 – TEMPERATURE COEFFICIENTS



MM3905 (SILICON)
MM3906

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3905 and 2N3906.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings — BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

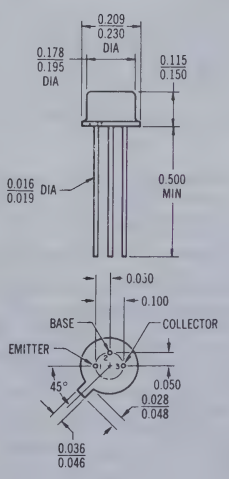


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW



CASE 27
(TO-52)

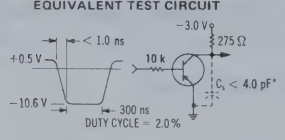
MM3905, MM3906 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		-	BV_{CBO}	40	-	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		-	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		-	I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		-	I_{BL}	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain			h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3905	15		30	-	
	MM3906			60	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3905			40	-	
	MM3906			80	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3905			50	150	
	MM3906			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3905			30	-	
	MM3906			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3905			10	-	
	MM3906			15	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		16, 17	$V_{CE(sat)}$	-	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.4	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		17	$V_{BE(sat)}$	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3905	-	f_T	200	-	MHz
	MM3906			250	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	13	h_{ie}	0.5	8.0	k ohms
	MM3906			2.0	12	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	14	h_{re}	0.1×10^{-4}	5×10^{-4}	-
	MM3906			1×10^{-4}	10×10^{-4}	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	11	h_{fe}	50	200	-
	MM3906			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	12	h_{oe}	1.0	40	μmhos
	MM3906			3.0	60	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	MM3905	9, 10	NF	-	5.0	dB
	MM3906			-	4.0	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3905	2, 7	t_s	-	200	ns
	MM3906			-	225	
Fall Time	MM3905	2, 8	t_f	-	60	ns
	MM3906			-	75	

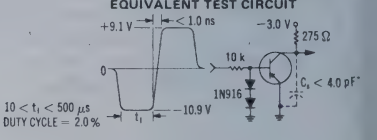
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



TRANSIENT CHARACTERISTICS

—T_J = 25°C ---T_J = 125°C

FIGURE 3 – CAPACITANCE

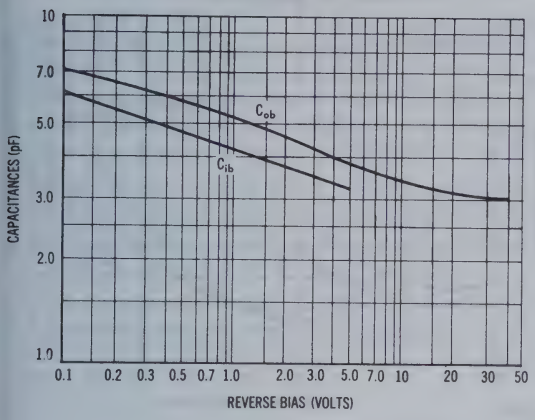


FIGURE 4 – CHARGE DATA

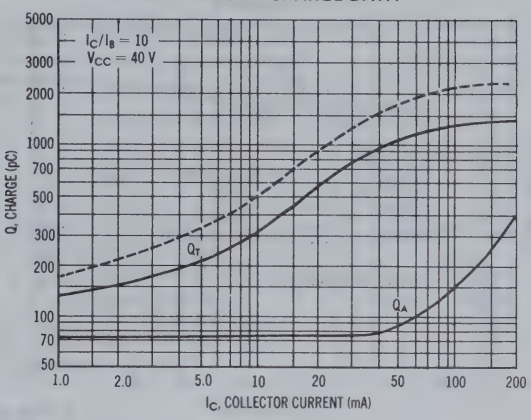


FIGURE 5 – TURN-ON TIME

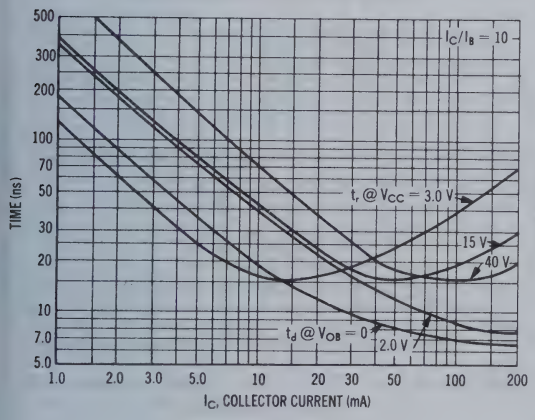


FIGURE 6 – RISE TIME

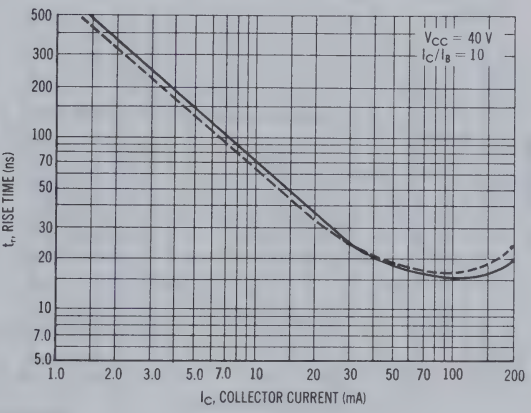


FIGURE 7 – STORAGE TIME

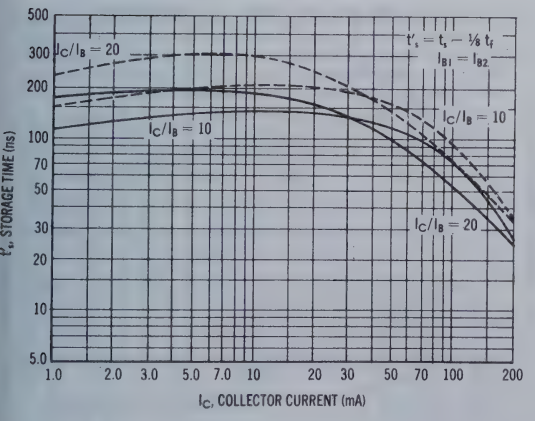
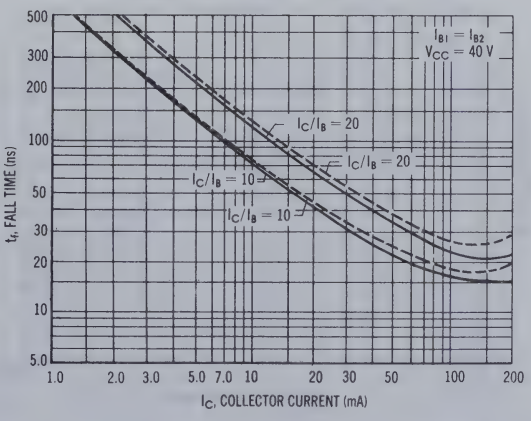


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

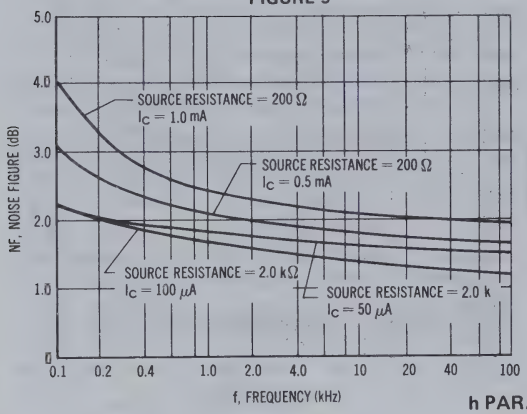
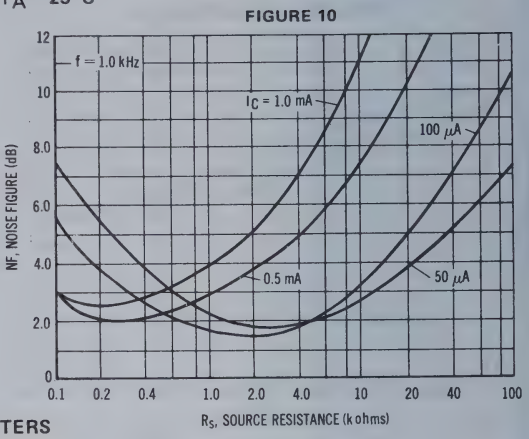


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 11 – CURRENT GAIN

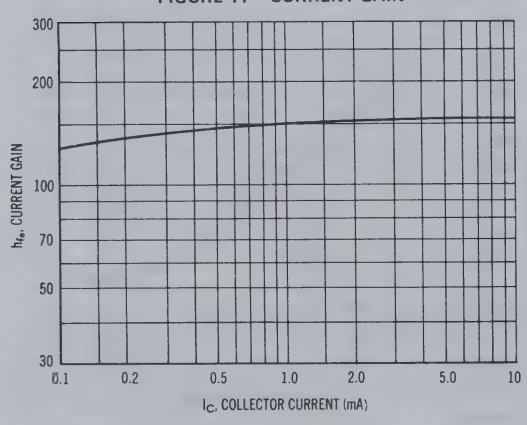


FIGURE 12 – OUTPUT ADMITTANCE

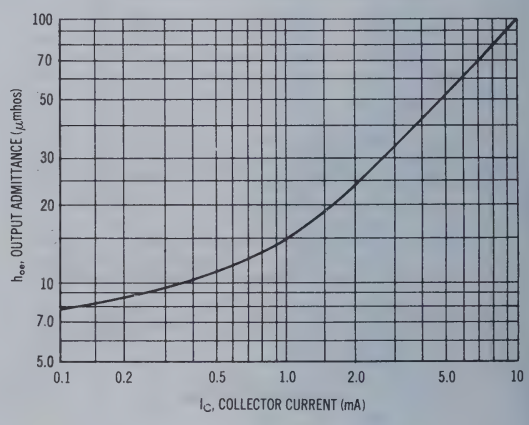


FIGURE 13 – INPUT IMPEDANCE

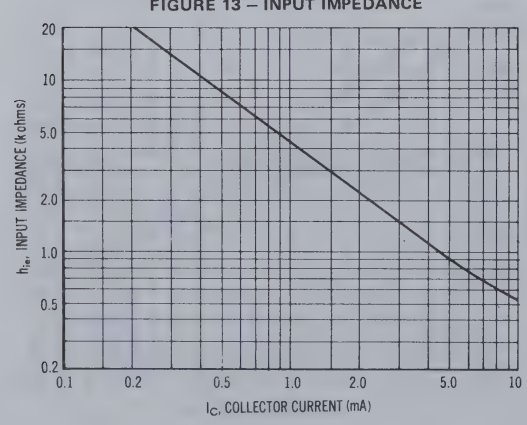
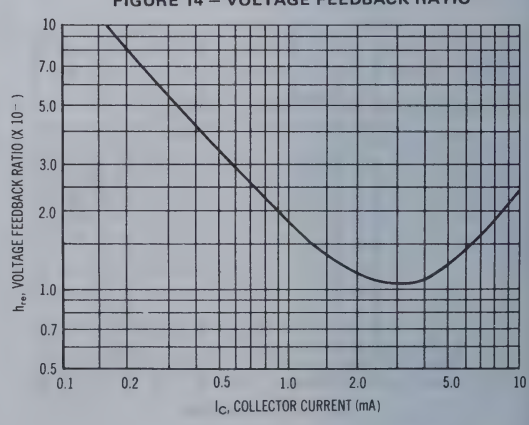


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – NORMALIZED CURRENT GAIN

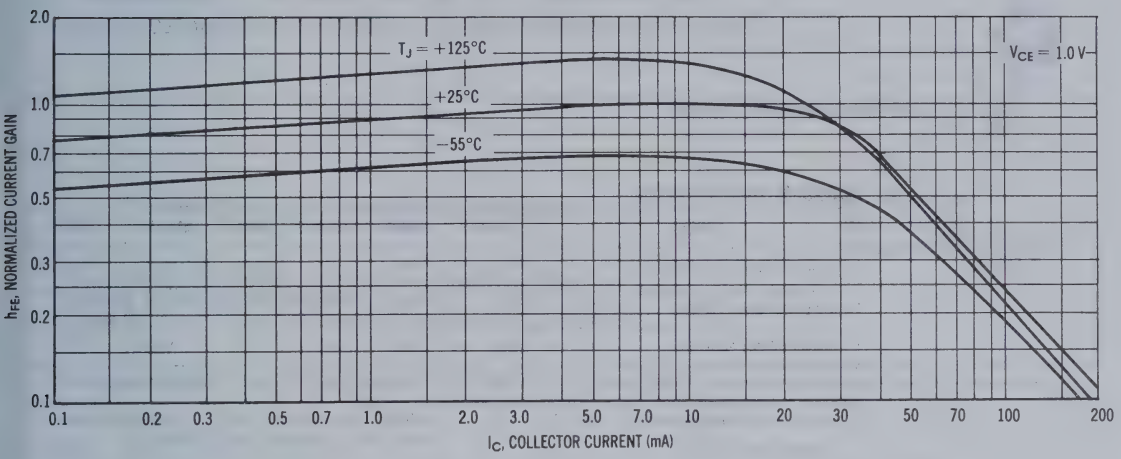


FIGURE 16 – COLLECTOR SATURATION REGION

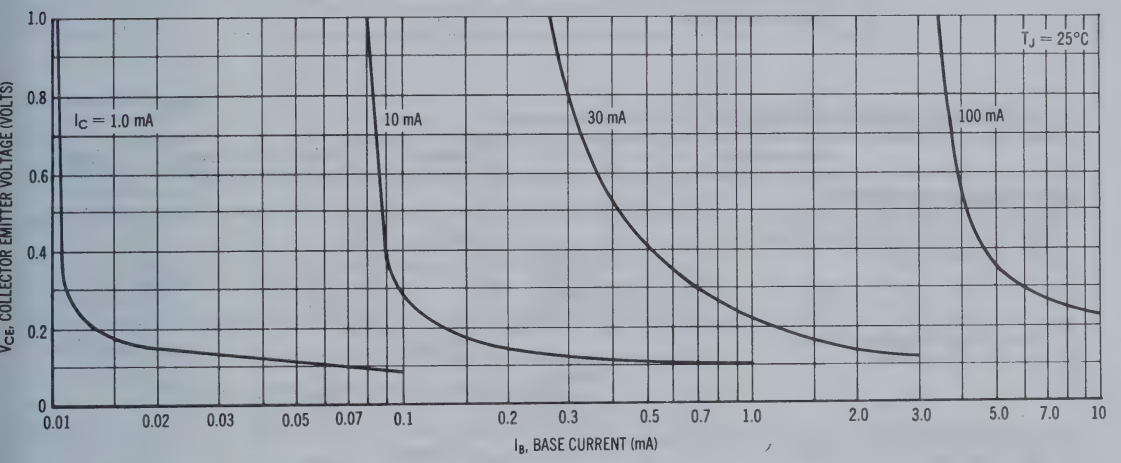


FIGURE 17 – "ON" VOLTAGES

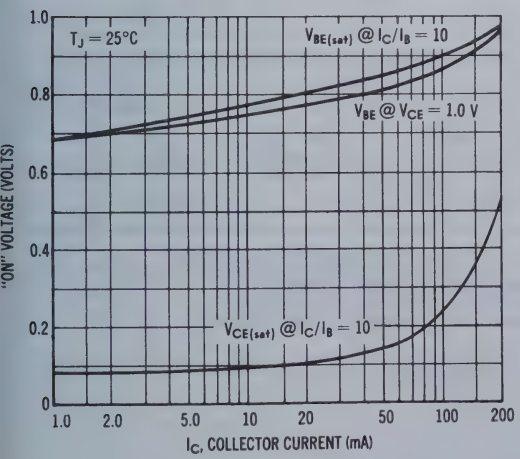
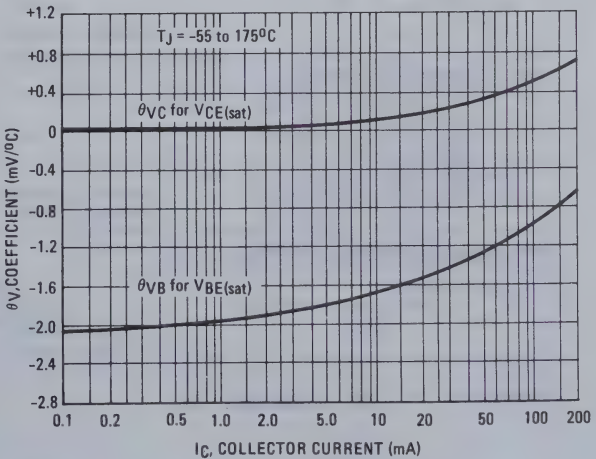


FIGURE 18 – TEMPERATURE COEFFICIENTS



MM4000 thru MM4003 (SILICON)



High-voltage PNP silicon annular transistors for use in general-purpose, high-voltage applications.

Collector connected to case

CASE 79
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.6	1.0	1.0	1.0	Watt
Derate above 25°C		3.4	5.71	5.71	5.71	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	5.0	5.0	5.0	Watts
Derate above 25°C		17.2	28.6	28.6	28.6	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM4000	BV_{CEO}	100	-	Vdc
	MM4001		150	-	
	MM4002		200	-	
	MM4003		250	-	
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	MM4000	BV_{CBO}	100	-	Vdc
	MM4001		150	-	
	MM4002		200	-	
	MM4003		250	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MM4000	I_{CBO}	-	1.0	μAdc
(V_{CB} = 75 Vdc, I_E = 0)	MM4001		-	1.0	
(V_{CB} = 150 Vdc, I_E = 0)	MM4002, MM4003		-	5.0	
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	-	-
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	MM4000, MM4001	$V_{CE(sat)}$	-	0.6	Vdc
	MM4002, MM4003		-	5.0	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4000	C_{ob}	-	6.0	pF
	MM4001		-	10	
	MM4002, MM4003		-	20	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

MM4018 (SILICON)

PNP SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C driver, or pre-driver stages in VHF applications.

- Power Output – P_{out} = 0.5 W (Min) @ f = 175 MHz
- High Current-Gain – Bandwidth Product – f_T = 900 MHz (Typ) @ I_C = 50 mAdc

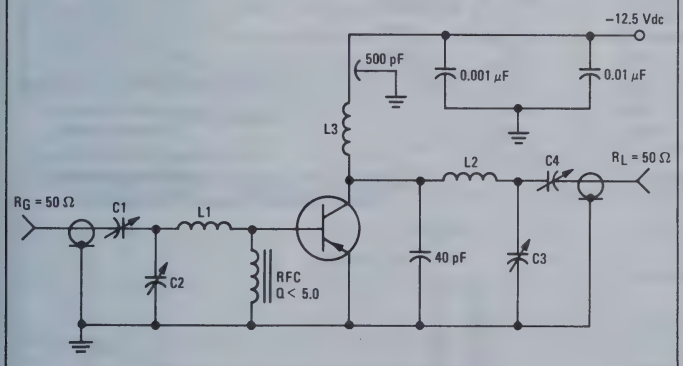
PNP SILICON RF POWER TRANSISTOR



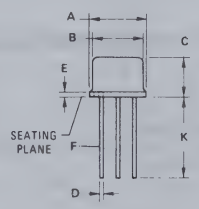
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

FIGURE 1 – 175 MHz OUTPUT POWER TEST CIRCUIT



C1, C2 3.0 – 30 pF, ARCO 461 OR EQUIVALENT
C3, C4 8.0 – 80 pF, ARCO 462 OR EQUIVALENT
L1 100 nH, 4 TURNS NO. 18 AWG, 1/4" I.D., 5/8" LENGTH
L2 40 nH, 2 TURNS NO. 18 AWG, 1/4" I.D., 1/2" LENGTH
L3 200 nH, 8 TURNS NO. 18 AWG, 1/4" I.D., 7/8" LENGTH



Pin 1. Emitter
2. Base
3. Collector

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.016	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

All JEDEC dimensions and notes apply

Collector connected to case.
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	20	μAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	–	–	0.1	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	900	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	–	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	P_{out}	0.5	–	–	Watt
Collector Efficiency (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	45	55	–	%

FIGURE 2 – POWER OUTPUT versus POWER INPUT

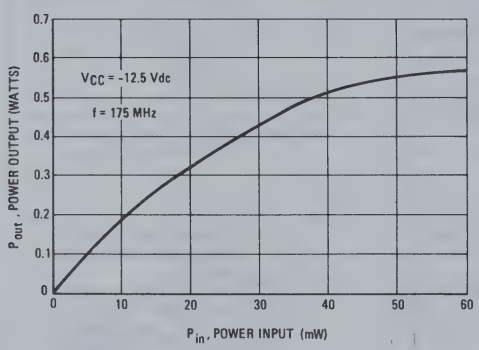


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

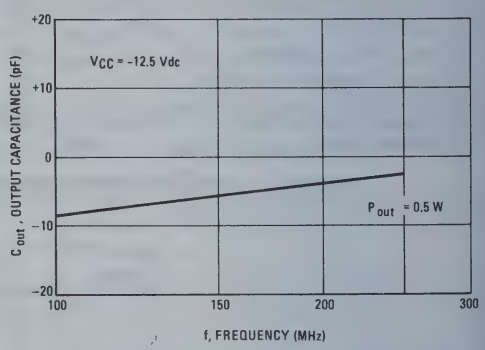


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

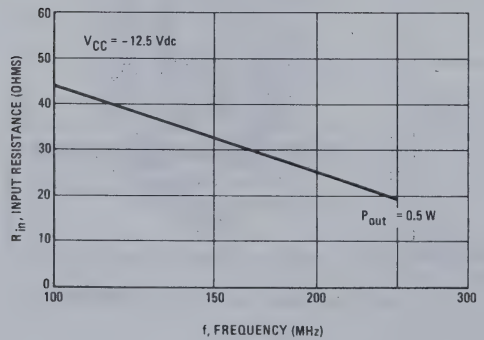
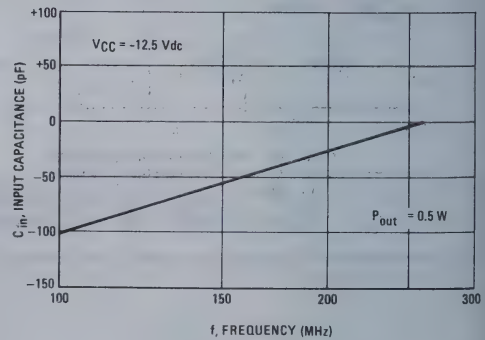


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019 (SILICON)

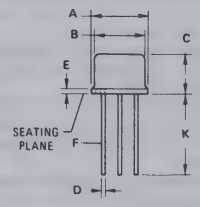
PNP SILICON RF POWER TRANSISTOR

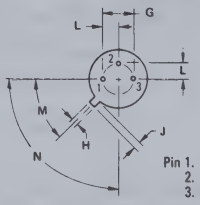
. . . designed for use as complement to NPN 2N3553 in VHF and UHF amplifier applications for military and industrial equipment.

- Power Output – P_{out} = 2.0 W (Typ) @ P_{in} = 0.5 W, f = 400 MHz
- Power Input – P_{in} = 0.25 W (Max) @ P_{out} = 2.5 W, f = 175 MHz

PNP SILICON RF POWER TRANSISTOR







Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.016	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

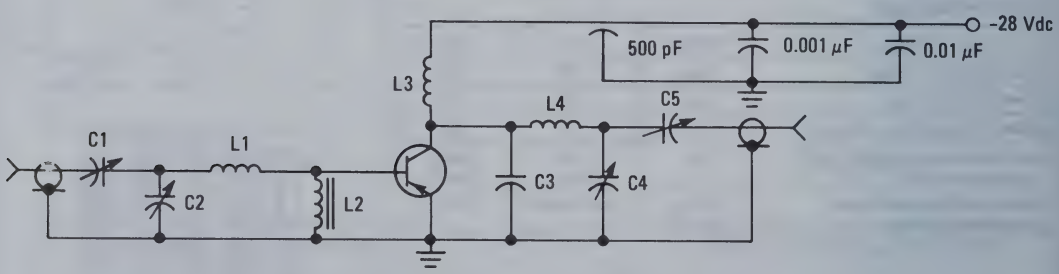
All JEDEC dimensions and notes apply

Collector connected to case.
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25° unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	–	750	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	7.5	–	pF
FUNCTIONAL TEST					
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	–	–	0.25	Watt
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	–	2.0	–	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT



C1, C2 3.0-30 pF, ARCO 461 or equivalent.
C3 40 pF
C4, C5 5.0-80 pF, ARCO 462 or equivalent.
L1 80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2 Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3 0.15 μH, RF Choke
L4 27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

FIGURE 2 – POWER OUTPUT versus FREQUENCY

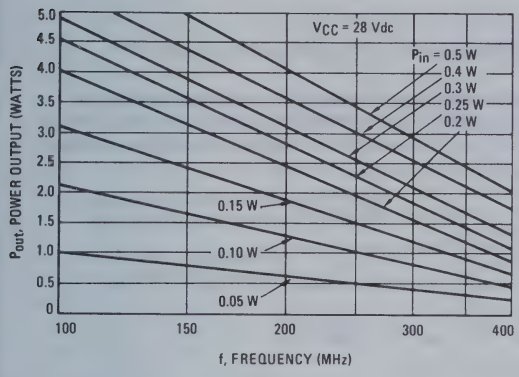


FIGURE 3 – POWER OUTPUT versus POWER INPUT

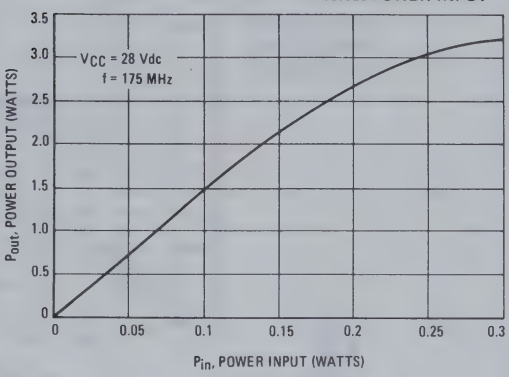


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

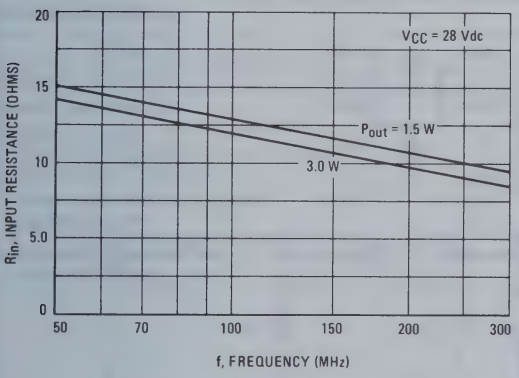


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

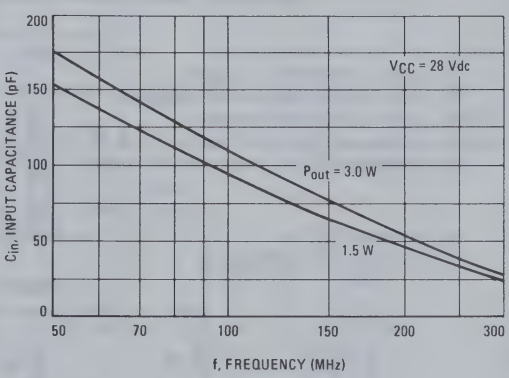


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

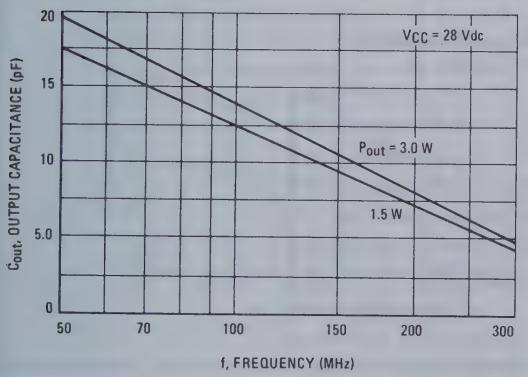


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

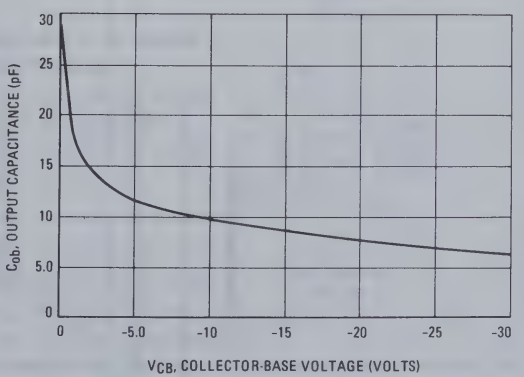


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

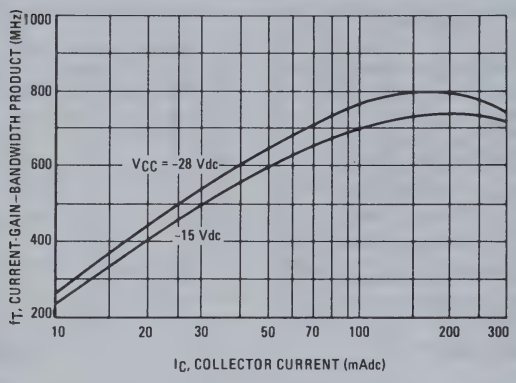


FIGURE 9 – MM4019/2N3553 COMPLEMENTARY 175 MHz AMPLIFIER CIRCUIT

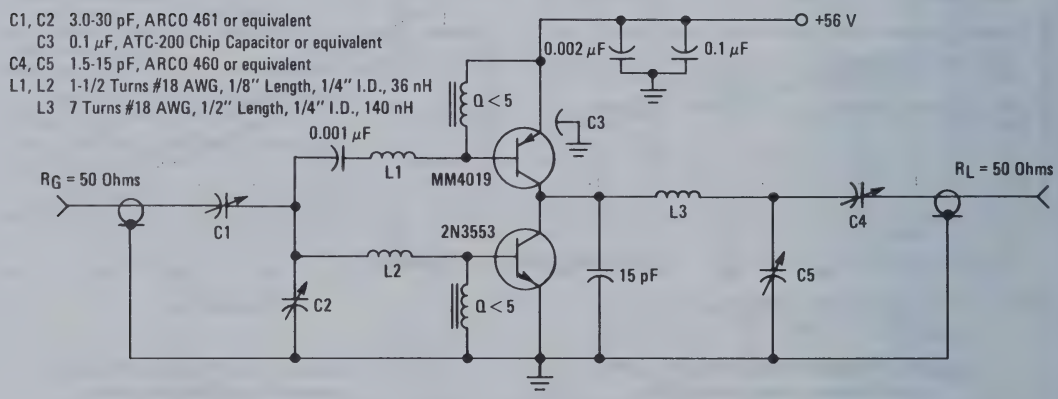
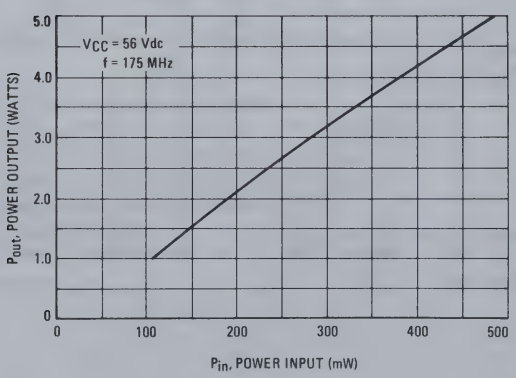


FIGURE 10 – POWER OUTPUT versus POWER INPUT FOR COMPLEMENTARY CIRCUIT



MM4049 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use as a high-frequency current mode switch. Because of the extremely high Current-Gain—Bandwidth this transistor also makes an excellent RF amplifier and oscillator.

- High Current-Gain—Bandwidth Product —
  f_T = 4.0 GHz (Min) @ I_C = 12 mAdc
- Low Output Capacitance —
  C_{ob} = 0.8 pF (Typ) @ V_{CB} = 5.0 Vdc

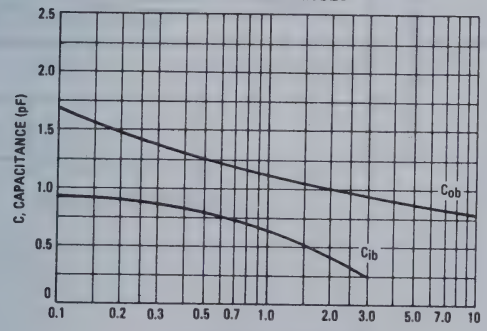
PNP SILICON SWITCHING TRANSISTOR

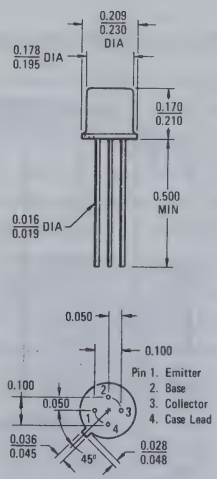


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 — CAPACITANCES





CASE 20 (10)
TO—72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20	80	–
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (Figure 2) (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz)	f_T	4.0	–	GHz
Output Capacitance (Figure 1) (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.25	pF
Input Capacitance (Figure 1) (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	1.25	pF
Collector-Base Time Constant (Figure 3) (I_E = 15 mAdc, V_{CB} = 5.0 Vdc, f = 63.6 MHz)	$r_b'C_c$	–	15	ps

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

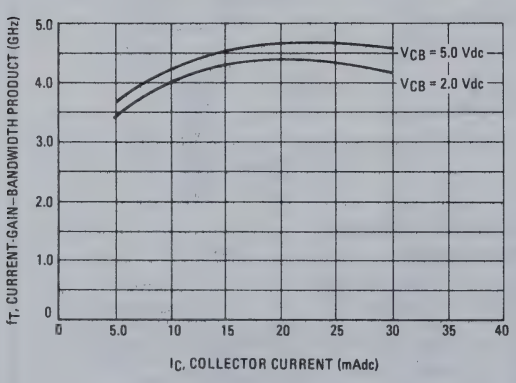
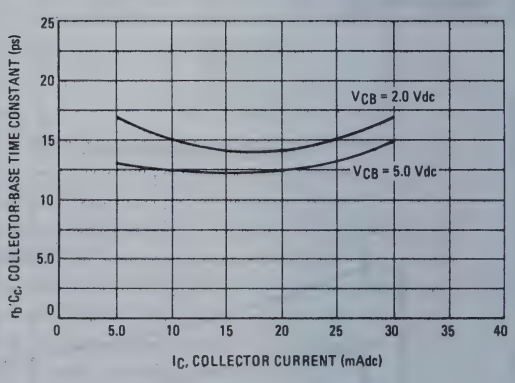


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT



MM4052 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for bilateral switching and high-level chopper applications such as servo-loop circuitry and control amplifiers for motor drive systems. These transistors can also be used as replacement devices for alloy-type transistors where high BV_{EBO} is required.

- High Emitter–Base Breakdown Voltage –
  BV_{EBO} = 30 Vdc (Min) @ I_E = 100 μAdc
- Inverted DC Current Gain – 3.0 (Min) @ I_C = 150 mAdc
- Low Emitter-Collector Offset Voltage –
  $V_{EC(ofs)}$ = 2.0 mVdc (Max) @ I_B = 1.0 mAdc
- Low "ON" Series Resistance –
  $r_{ec(ON)}$ = 2.0 Ohms (Max) @ I_B = 10 mAdc

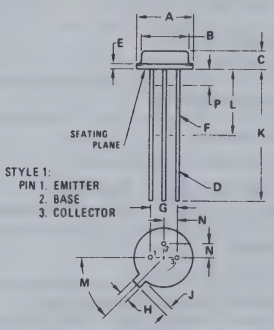
PNP SILICON CHOPPER AND SWITCHING TRANSISTOR

DS 5361



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Collector Voltage	V_{EC}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25° C Derate above 25° C	P_D	0.5 2.8	Watt mW/°C
Total Device Dissipation @ T_C = 25 C Derate above 25 C	P_D	1.75 10	Watts mW/ C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25° C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Emitter-Collector Breakdown Voltage [1] (I_E = 10 mAdc, I_B = 0)	BV_{ECO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	30	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	nAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	–	0.5	nAdc
ON CHARACTERISTICS				
DC Current Gain [1]	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		20	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		15	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (Inverted)		3.0	–	
Offset Voltage (I_B = 1.0 mAdc, I_E = 0)	$V_{EC(ofs)}$	–	2.0	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{EB} = 10 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ib}	–	5.0	pF
Small-Signal Current Gain	h_{fe}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)		20	–	–
(I_C = 10 mAdc, V_{CE} - 1.0 Vdc, f = 4.0 MHz)		3.0	–	–
"ON" Series Resistance (I_B = 10 mAdc, f = 1.0 kHz)	$r_{ec(ON)}$	–	2.0	Ohms

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 20%

MM4208, MM4208A (SILICON)
MM4209, MM4209A

PNP SILICON ANNULAR TRANSISTORS

. . . designed for applications requiring very high-speed switching at low voltage for computer logic circuits.

- Fast Switching Times – @ I_C = 50 mAdc
  t_{on} = 15 ns (Max)
  t_{off} = 20 ns (Max)
- High Current-Gain–Bandwidth Product –
  f_T = 1300 MHz (Typ) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.18 Vdc (Max) @ I_C = 10 mAdc

PNP SILICON SWITCHING TRANSISTORS

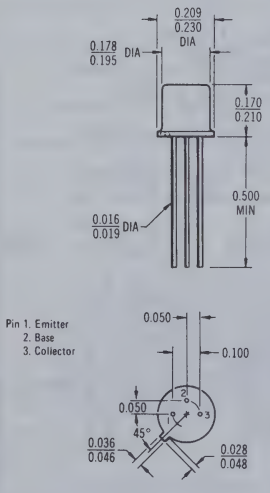


MAXIMUM RATINGS

Rating	Symbol	MM4208 MM4209	MM4208A MM4209A	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Base Voltage	V_{CB}	12	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

SELECTOR GUIDE

Type	BV_{CEO} Volts Min	h_{FE} @ I_C = 10 mA, V_{CE} = 0.3 V Min / Max
MM4208 MM4208A	12 15	30/120 30/120
MM4209 MM4209A	12 15	50/120 50/120



Collector Connected to Case

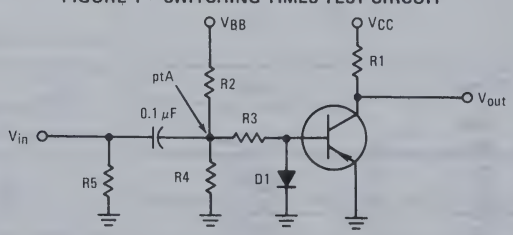
CASE 22 (1)
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 3.0 mAdc, I_B = 0)	MM4208,MM4209	BV_{CEO}	12	–	–	Vdc
	MM4208A,MM4209A		15	–	–	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MM4208,MM4209	BV_{CES}	12	–	–	Vdc
	MM4208A,MM4209A		15	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4208,MM4209	BV_{CBO}	12	–	–	Vdc
	MM4208A,MM4209A		15	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current		I_{CES}				
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MM4208,MM4209		–	–	10	nAdc
(V_{CE} = 8.0 Vdc, V_{BE} = 0)	MM4208A,MM4209A		–	–	10	
(V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 125°C)	MM4208,MM4209		–	–	5.0	μAdc
(V_{CE} = 8.0 Vdc, V_{BE} = 0, T_A = 125°C)	MM4208A,MM4209A		–	–	5.0	
Base Current		I_B				nAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MM4208,MM4209		–	–	1.0	
(V_{CE} = 8.0 Vdc, V_{BE} = 0)	MM4208A,MM4209A		–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	MM4208,MM4208A		15	–	–	
	MM4209,MM4209A		35	–	–	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	MM4208,MM4208A		30	–	120	
	MM4209,MM4209A		50	–	120	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_A = -55°C)	MM4208,MM4208A		12	–	–	
	MM4209,MM4209A		20	–	–	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1)	MM4208,MM4208A		30	–	–	
	MM4209,MM4209A		40	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	–	0.15	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	–	0.18	
(I_C = 50 mAdc, I_B = 5.0 mAdc)(1)			–	–	0.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	–	0.8	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.7	–	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)(1)			–	–	1.5	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	850	1300	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	–	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	–	3.5	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)		t_{on}	–	–	15	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)		t_{off}	–	–	20	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C ≈ 10 mAdc, I_{B1} = I_{B2} ≈ 10 mAdc)		t_s	–	17	20	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	R4 Ohms	R5 Ohms	D1
t_{on}	-12.8	+4.0	-3.0	55	100	2.0 k	100	inf.	no
t_{off}	+20	-11.3*	-3.0	55	100	2.0 k	100	inf.	yes
t_s	+9.0	-10	-3.0	270	510	390	inf.	51	no

*At Point A (ptA)

MM4257 (SILICON)
MM4258

PNP SILICON ANNULAR TRANSISTORS

. . . designed for applications requiring high speed switching at low voltages.

- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.15 Vdc (Max) @ I_C = 10 mAdc
- Switching Times @ I_C = 10 mAdc —
  t_{on} = 10 ns (Typ)
  t_{off} = 10 ns (Typ)
- Hermetic Constructed Version of 2N4257 and 2N4258
- Complement to 2N2369

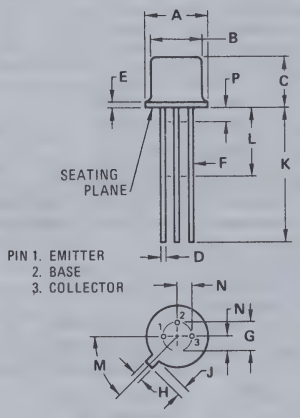
SWITCHING TRANSISTORS

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	MM4257	MM4258	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	12	Vdc
Collector-Base Voltage	V_{CB}	6.0	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Continuous	I_C	80		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	

Collector Connected to Case

CASE 22
TO-18

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$				Vdc
(I_C = 3.0 mAdc, I_B = 0)	MM4257		6.0	–	–	
	MM4258		12	–	–	
Collector-Emitter Breakdown Voltage (1)		BV_{CES}				Vdc
(I_C = 100 μAdc, V_{BE} = 0)	MM4257		6.0	–	–	
	MM4258		12	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	MM4257		6.0	–	–	
	MM4258		12	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}	4.5	–	–	Vdc
(I_E = 100 μAdc, I_C = 0)						
Collector Cutoff Current		I_{CES}				μAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0)			–	–	0.01	
(V_{CE} = 3.0 Vdc, V_{BE} = 0, T_A = +65°C)			–	–	5.0	
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)			15	–	–	
(I_C = 10 mAdc, V_{CE} = 3.0 Vdc)			30	–	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	–	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.75	–	0.95	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	–	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (2)		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	MM4257		500	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MM4258		700	–	–	
Collector-Base Capacitance		C_{cb}	–	–	3.0	pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)						
Input Capacitance		C_{ib}	–	–	3.5	pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)						
SWITCHING CHARACTERISTICS (Figure 5)						
Turn-On Time	(V_{CC} = 1.5 Vdc, $V_{BE(off)}$ = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	–	10	15	ns
Delay Time		t_d	–	5.0	10	ns
Rise Time		t_r	–	5.0	15	ns
Turn-Off Time	(V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM4257	t_{off}	–	12	15	ns
	MM4258		–	16	20	
Storage Time	MM4257	t_s	–	6.0	15	ns
	MM4258		–	8.0	20	
Fall Time	MM4257	t_f	–	6.0	10	ns
	MM4258			8.0	10	
Storage Time ($I_C \approx 10$ mAdc, $I_{B1} \approx 10$ mAdc, $I_{B2} \approx 10$ mAdc)	MM4257	t_s	–	–	15	ns
	MM4258		–	–	20	

(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

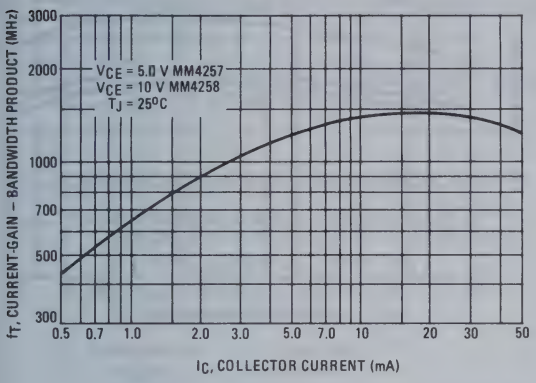


FIGURE 2 – CAPACITANCE

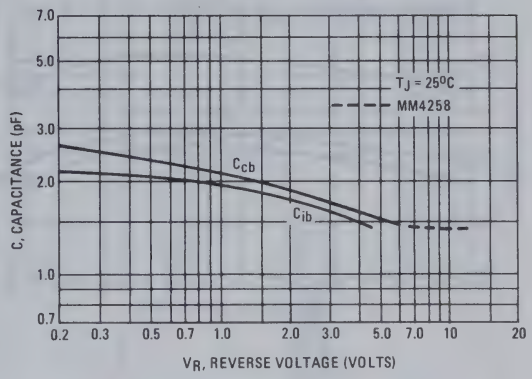


FIGURE 3 – TURN-ON TIME

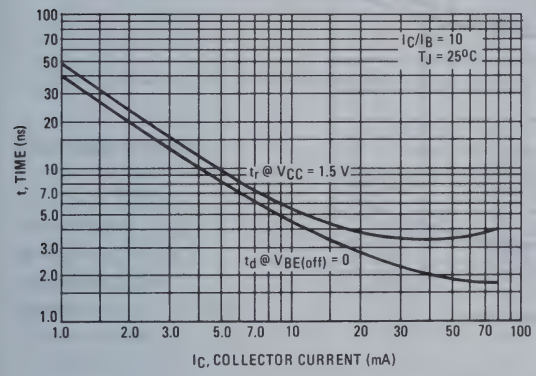


FIGURE 4 – TURN-OFF TIME

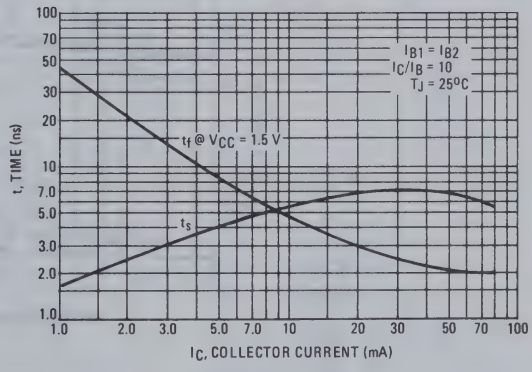
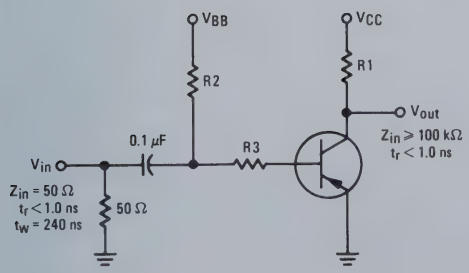


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

DC CURRENT GAIN

FIGURE 6 – MM4257

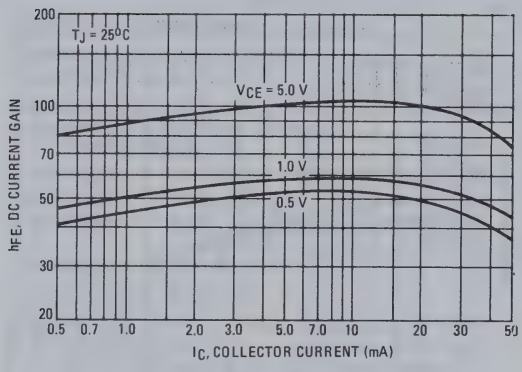


FIGURE 7 – MM4258

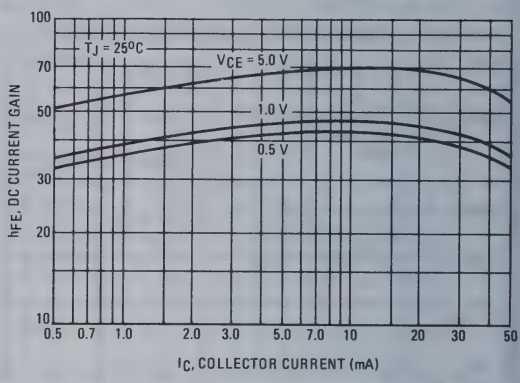
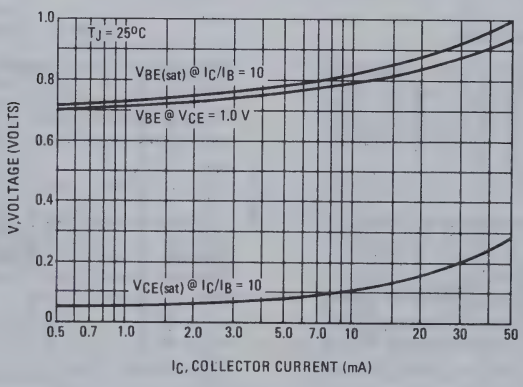


FIGURE 8 – "ON" VOLTAGES



MM4261H (SILICON)

High Reliability Products

PNP SILICON ANNULAR TRANSISTOR

. . . designed for high reliability, low-level switching applications and general usage for radiation resistant requirements.

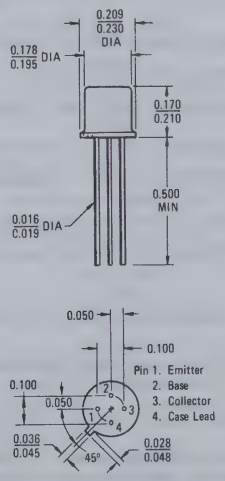
- Off-the-Shelf Availability of Extensive High Reliability Processing
- High Tolerance to Neutron Radiation @ I_C = 10 mA, h_{FE} Degradation Typically Less Than 50% after 5×10^{14} Neutrons/cm^2 (Figure 13)
- High Current-Gain–Bandwidth Product — f_T = 3500 MHz (Typ) @ I_C = 10 mA
- Low Input and Output Capacitance — C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance — t_r = 0.5 ns (Typ) @ I_C = 10 mA
  1.1 ns (Typ) @ I_C = 30 mA

PNP SILICON SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



CASE 20 (10)
TO–72

HIGH RELIABILITY PROCESSING SEQUENCE

The lot is 100% inspected in the sequence shown below

↓

INTERNAL VISUAL INSPECTION
Note 1

SCREEN ELECTRICAL PARAMETERS
Table I
G,R

HIGH TEMPERATURE STORAGE
$T_A \geq 200^oC$, $t \geq 24$ hours

TEMPERATURE CYCLING
MIL-STD-202, Method 102, Condition C
10 cycles, t (extreme) ≥15 minutes

CONSTANT ACCELERATION
MIL-STD-750, Method 2006
Y1 axis 20,000 G

FINE LEAK
MIL-STD-202, Method 112, Procedure IIIa
Condition C, P = 50 psig, t = 4 hours
Leak rate $\leq 1 \times 10^{-8}$ atm. cc/sec
R

GROSS LEAK
MIL-STD-202, Method 112, Condition A
Ethylene Glycol, $T = 100^oC$, $t \geq 15$ sec.
R

MARK DEVICES
Motorola Symbol, MM4261H, seal date code

ELECTRICAL TEST Table II (initial)
RR,R

BURN-IN $T_A = 25^oC$, t = 168 hours
$P_D = 200$ mW, $V_{CB} \leq 5.0$ V

ELECTRICAL TEST Table II (end points)
$P_{DA} = 10$
RR,R

Option 1
Burn-In Data with Delta Calculations
(see Option Data Provisions)

Samples are randomly selected from the lot for Group A, Group B, and Group C inspection. Sample size for each Subgroup shall be determined from Sampling Plan Table and shall meet the specified LTPD or lambda requirements.

NOTE 1: Internal Visual Inspection

Each device will be inspected under magnification for defects in material and workmanship which do not comply with Motorola's visual inspection procedures.

GROUP A INSPECTION

SAMPLE INSPECT ELECTRICAL PARAMETERS per TABLE I
summary data provided

SUBGROUP 1
LTPD = 5

VISUAL and MECHANICAL
MIL-STD-750
Method 2071
R

SUBGROUP 2
LTPD = 2

ELECTRICAL TEST
Table I
G,R

SUBGROUP 3
LTPD = 3

ELECTRICAL TEST
Table I
G,R

SUBGROUP 4
LTPD = 5

ELECTRICAL TEST
Table I
G,R

SUBGROUP 5
LTPD = 5

ELECTRICAL TEST
Table I
G,R

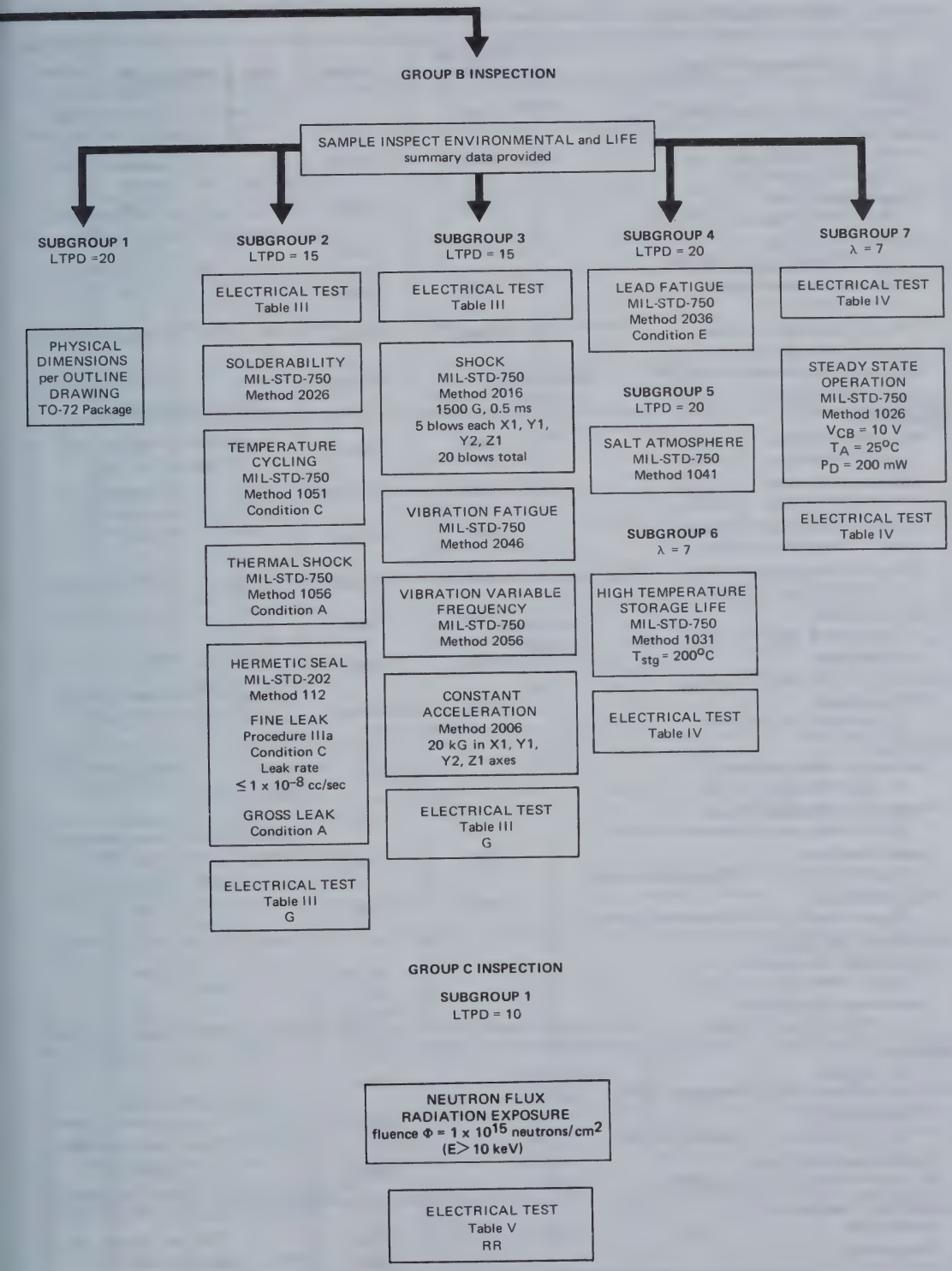
SUBGROUP 6
LTPD = 7

ELECTRICAL TEST
Table I
G,R

SUBGROUP 7
LTPD = 7

ELECTRICAL TEST
Table I
G,R

R — Remove Rejects
G — Go-No-Go
RR — Read and Record



G – Go-No-Go

RR – Read and Record

TABLE I: GROUP A INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	–	–	–	–	5
SUBGROUP 2						2
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	3041A	I_{CEX1}	–	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(on)}$ = 0.4 Vdc)	3041A	I_{CEX2}	–	50	nAdc	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	3026D	BV_{EBO}	4.5	–	Vdc	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	3001D	BV_{CBO}	15	–	Vdc	
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	3011D	BV_{CEO}	15	–	Vdc	
SUBGROUP 3						3
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)1}$	–	0.8	Vdc	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)2}$	–	1.0	Vdc	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	3071	$V_{CE(sat)1}$	–	0.15	Vdc	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$	–	0.35	Vdc	
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE1}	25	–	–	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	–	
DC Current Gain (I_C = 30 mAdc, V_{CE} = 2.0 Vdc)	3076	h_{FE3}	20	–	–	
SUBGROUP 4						5
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		f_{T1}	1500	–	MHz	
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_{T2}	2000	–	MHz	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, 100 kHz≤ f ≤1.0 MHz)	3236	C_{ob}	–	2.5	pF	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, 100 kHz≤ f ≤1.0 MHz)	3240	C_{ib}	–	2.5	pF	
SUBGROUP 5 (See Figure 1)						5
Collector-Base Time Constant (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)		$r_b'C_{c1}$	–	60	ps	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc)		$r_b'C_{c2}$	–	50	ps	
SUBGROUP 6						7
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		h_{FE4}	15	–	–	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		h_{FE5}	15	–	–	
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		I_{CBO2}	–	5.0	μAdc	
SUBGROUP 7 (See Figure 2)						7
Turn-On Time		t_{on}	–	5.0	ns	
Turn-Off Time		t_{off}	–	5.0	ns	

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TABLE II: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	–
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater		ΔI_{CBO1}	–	–	–
DC Current Gain		Δh_{FE2}	–	±20%	–

TABLE III: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	–

TABLE IV: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

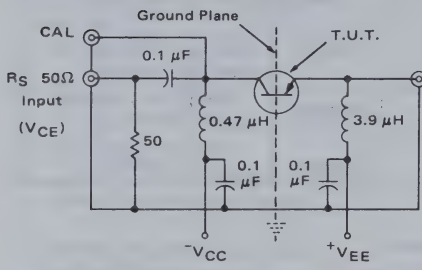
Examination or Test		MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	Initial	3036D	I_{CBO1}	–	5.0	nAdc
	End Point			–	10	
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	Initial	3076	h_{FE2}	30	150	–
	End Point			20	180	
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater			ΔI_{CBO1}	–	–	–
DC Current Gain			Δh_{FE2}	–	±20%	–

TABLE V: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	10	μAdc
Collector-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$	–	0.5	Vdc
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	12	–	–

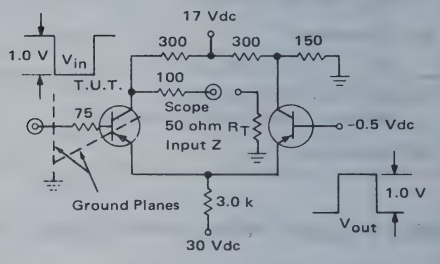
[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR-BASE TIME CONSTANT TEST CIRCUIT



1. With transistor under test removed from socket, set input level at "CAL" jack to 500 mV at 31.8 MHz. Insert transistor in socket.
2. After putting VTVM probe on "OUT" jack, adjust bias on transistor under test.
3. Reading on VTVB in millivolts multiplied by 10 equals $r_b'C_c$

FIGURE 2 – TURN-ON TIME AND TURN-OFF TIME TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identical circuits with input Z equal to output Z.

FIGURE 3 – DC CURRENT GAIN

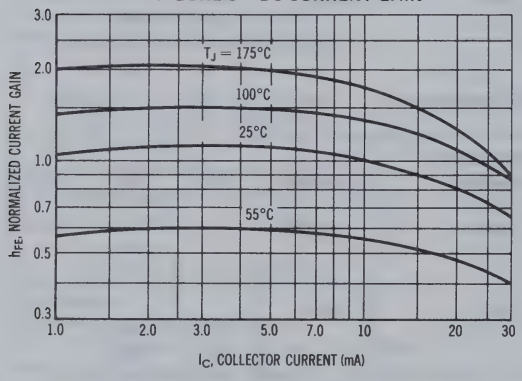


FIGURE 4 – COLLECTOR SATURATION REGION

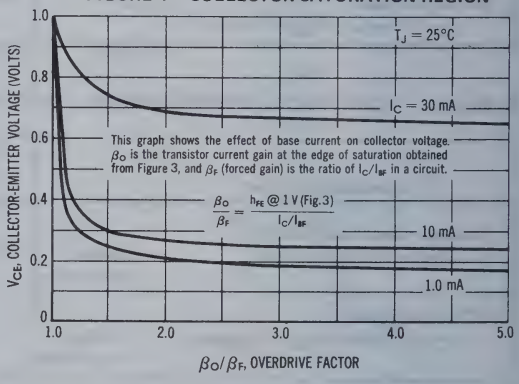


FIGURE 5 -- "ON" VOLTAGES

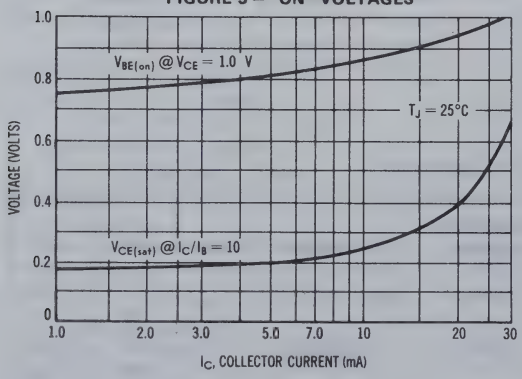


FIGURE 6 – TEMPERATURE COEFFICIENTS

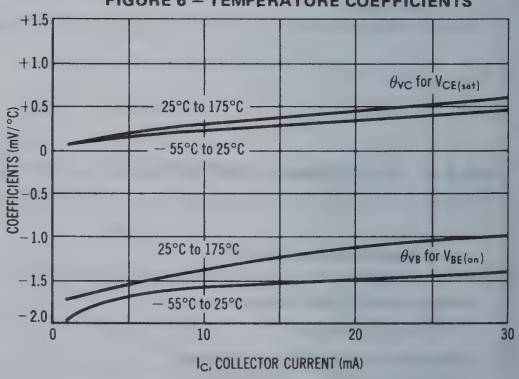


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

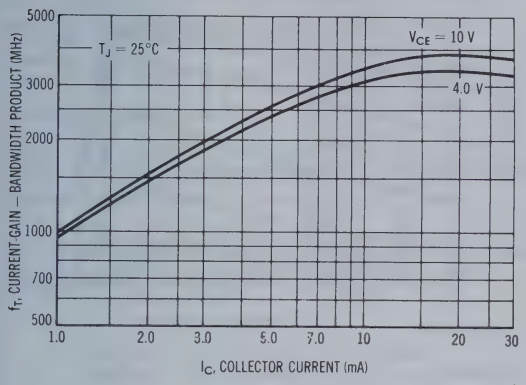


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

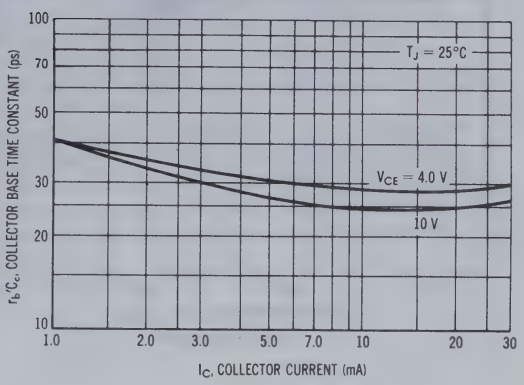


FIGURE 9 – CAPACITANCE

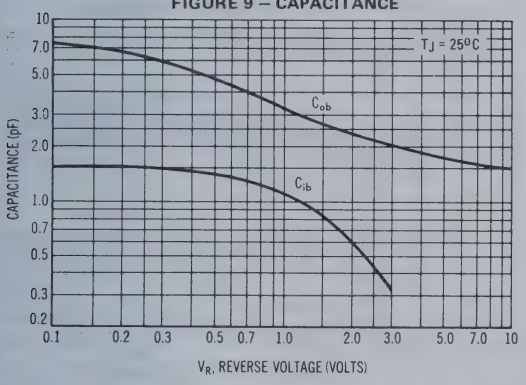


FIGURE 10 – SWITCHING TIMES

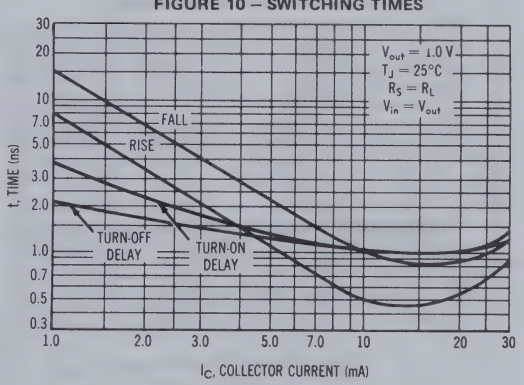
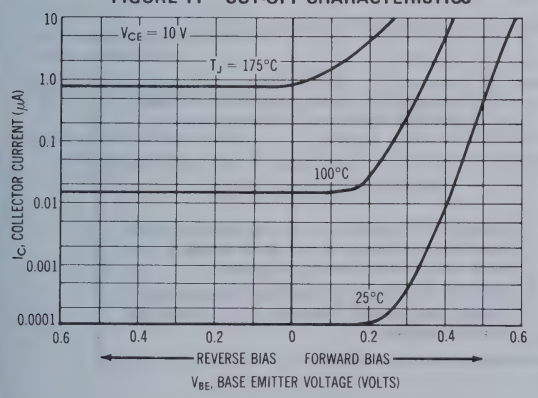


FIGURE 11 – CUT-OFF CHARACTERISTICS



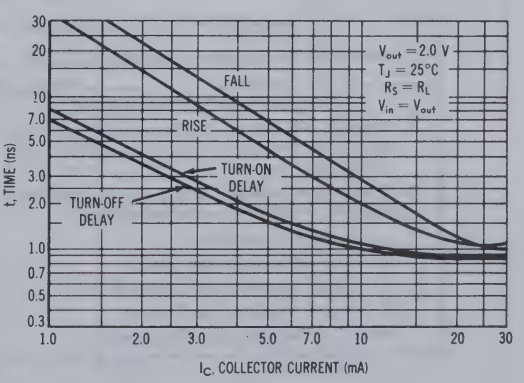


FIGURE 12 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

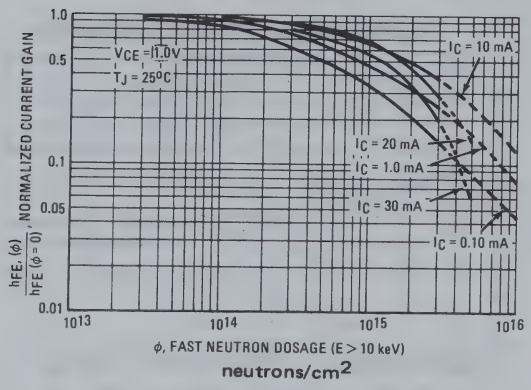


FIGURE 13 – TYPICAL DC CURRENT GAIN versus FAST NEUTRON DOSAGE

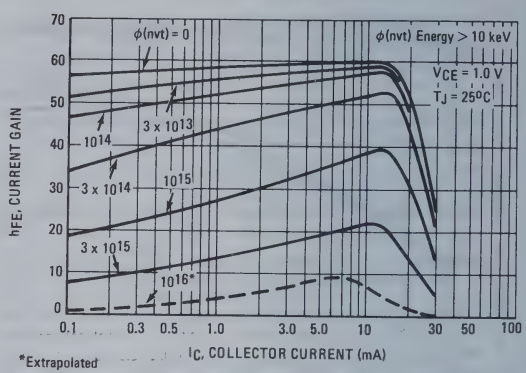


FIGURE 14 – COLLECTOR-BASE LEAKAGE CURRENT versus FAST NEUTRON DOSAGE

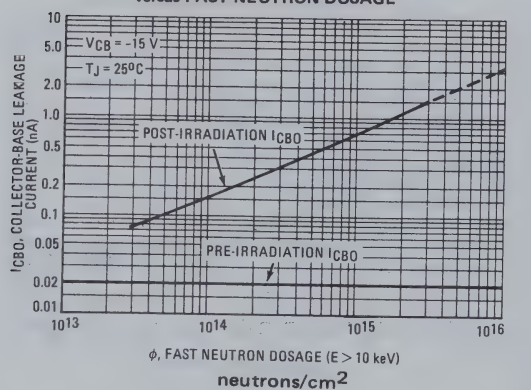
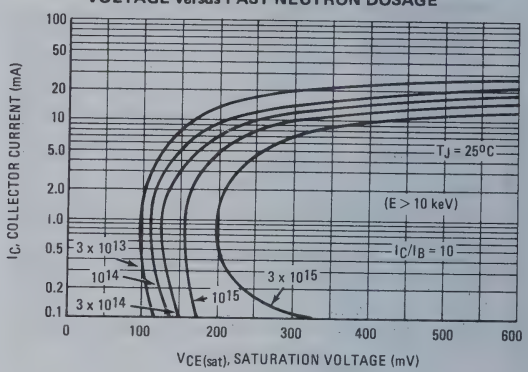


FIGURE 15 – TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE versus FAST NEUTRON DOSAGE



Devices Stocked in Motorola Bonded Warehouse	Option 2 100% Radiographic Inspection per MIL-STD-202, Method 209 (see Option Data Provisions)
STANDARD DATA PROVISIONS 1. Motorola will keep on file 1 copy of all associated data for a minimum of 3 years from date of purchase order. 2. One copy of Summary data shall accompany each shipment of devices from following steps. a. Burn-In Test per Table II b. Group A Inspection per Table I c. Group B Inspection per Tables III and IV d. Group C Inspection per Table V Foam Tray Packaging per MIL-S-19491	OPTION DATA PROVISIONS 1. Motorola will provide burn-in delta data on control parameters for the lot as well as for Group B, Subgroup 6 and 7, and Group C, Subgroup 1. 2. Motorola will X-ray the serialized devices prior to shipping and provide films only if this is required by purchase order.

MM4404, MM4404A

For Specifications, See MA4404 Data.

MM5005 (SILICON)
MM5006
MM5007

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage audio driver amplifier and general purpose switching and oscillator applications.

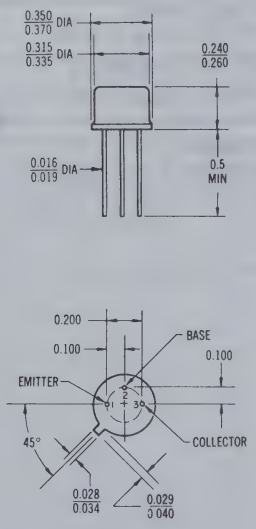
- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 100 Vdc (Min) @ I_C = 10 mAdc (MM5007)
- Low Output Capacitance —
  C_{ob} = 20 pF (Max) @ V_{CB} = 10 Vdc
- Excellent Current Gain Linearity — 1.0 to 250 mAdc
- Complements to NPN MM3005, MM3006, MM3007

PNP SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous	I_C	← 2.0 →			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.5 → ← 8.57 →			Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 8.0 → ← 45.7 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →			°C



CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MM5005	BV_{CEO}	60	–	Vdc
	MM5006		80	–	
	MM5007		100	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM5005	BV_{CBO}	80	–	Vdc
	MM5006		100	–	
	MM5007		120	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MM5005		–	200	
(V_{CB} = 80 Vdc, I_E = 0)	MM5006		–	200	
(V_{CB} = 100 Vdc, I_E = 0)	MM5007		–	200	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 2.5 Vdc)	All Types		40	–	
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	MM5005		50	250	
(I_C = 200 mAdc, V_{CE} = 2.5 Vdc)	MM5006		50	250	
(I_C = 250 mAdc, V_{CE} = 2.5 Vdc)	MM5007		50	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)		$V_{BE(on)}$	0.65	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	pF

MM8000 (SILICON)
MM8001



CASE 79
(TO-39)

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

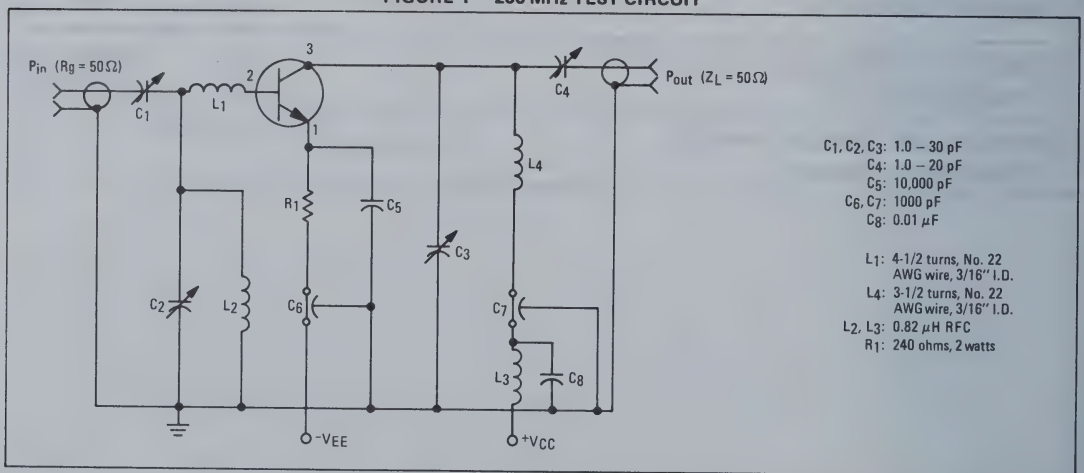
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

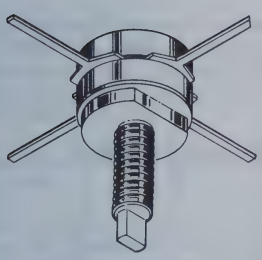
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	-	-	20	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)		h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		550	-	-	
	MM8001		700	-	-	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		700	-	-	
	MM8001		900	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		700	-	-	
	MM8001		900	-	-	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	-	3.5	pF
Noise Figure Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		NF	-	2.7	-	dB
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		G_{pe}	-	11.4	-	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



MM8003 (SILICON)



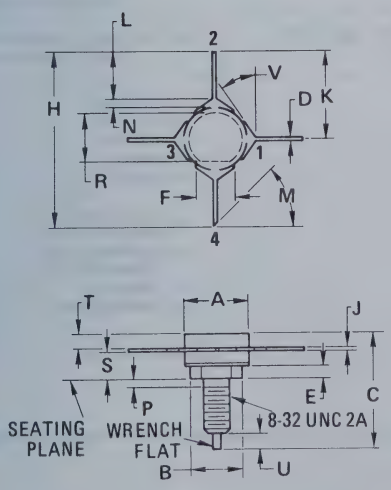
CASE 144B-03

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

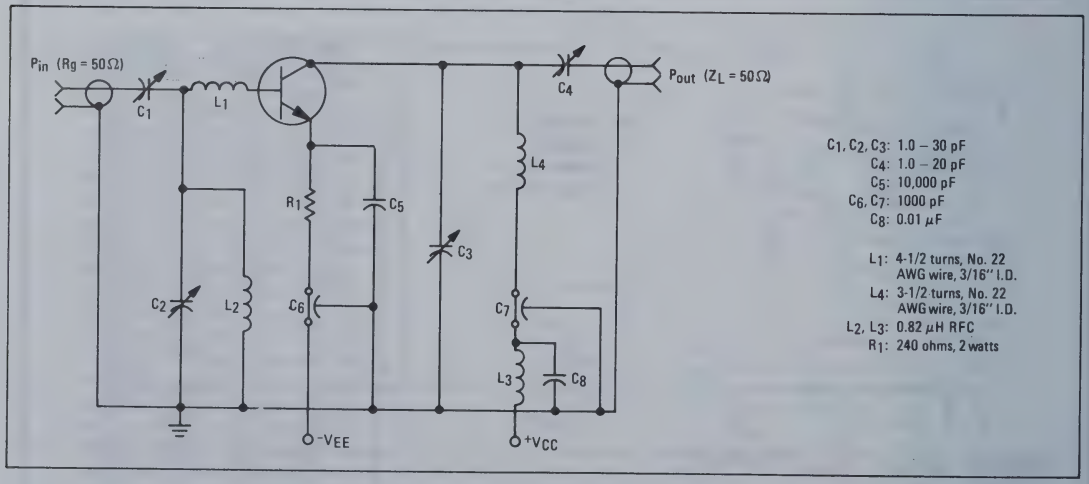
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	17.63	19.46	0.694	0.766
D	0.64	0.89	0.025	0.035
E	1.78	2.03	0.070	0.080
F	5.59	5.84	0.220	0.230
H	26.16	27.69	1.030	1.090
J	0.10	0.15	0.004	0.006
K	13.08	13.84	0.515	0.545
L	7.11	7.37	0.280	0.290
M	40°	50°	40°	50°
N	1.27	1.52	0.050	0.060
P		1.27		0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130
V	10°	20°	10°	20°

CASE 144B-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	-	-	20	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product	f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	-	-	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1200	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	-	-	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	-	4.0	pF
Noise Figure Figure 1 (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	-	2.7	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain Figure 1 (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	G_{pe}	-	11.4	-	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



MM8006 (SILICON)
MM8007

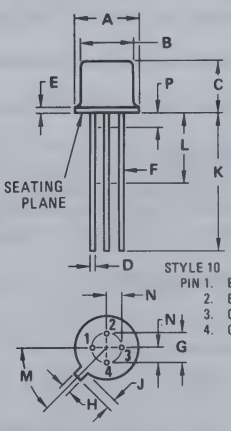
NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise, small-signal amplifiers in military and industrial equipment. Suitable for use in video wideband and general high-frequency amplifier applications of 50 to 1000 MHz.

- Low Noise Figure –
  NF = 2.2 dB (Typ) @ f = 200 MHz – MM8006
- High Power Gain –
  G_{pe} = 25 dB (Typ) @ f = 200 MHz – MM8006
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Min) @ I_C = 5.0 mAdc

NPN SILICON RF SMALL-SIGNAL TRANSISTORS





STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)		BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)		I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)		h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)		f_T	1000	–	3500	MHz
Collector-Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)		C_{cb}	–	1.1	1.5	pF
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	5.0	–	ps
Noise Figure		NF				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	MM8006		–	1.5	–	
	MM8007		–	1.9	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	2.2	–	
	MM8007		–	2.7	–	
†(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		–	–	3.8	
	MM8007		–	–	5.0	
FUNCTIONAL TEST						
†Common-Emitter Amplifier Power Gain		G_{pe}				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	Both Types		–	30	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	25	–	
	MM8007		–	20	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		14	–	–	
	MM8007		12	–	–	

†Tuned for minimum noise.

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

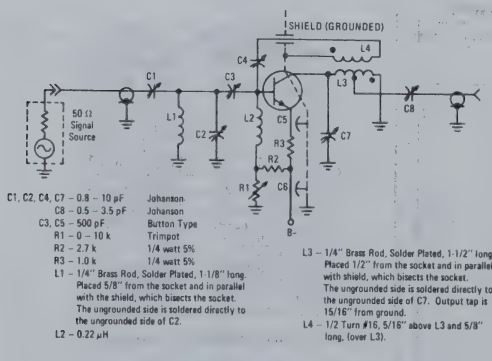


FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

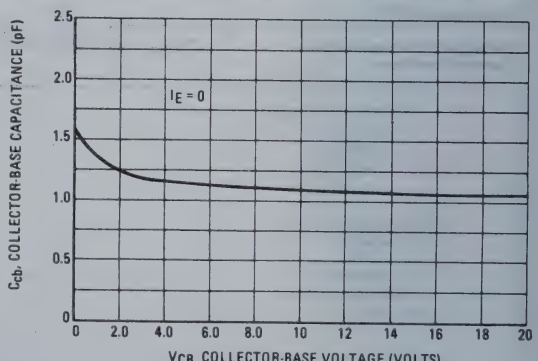


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

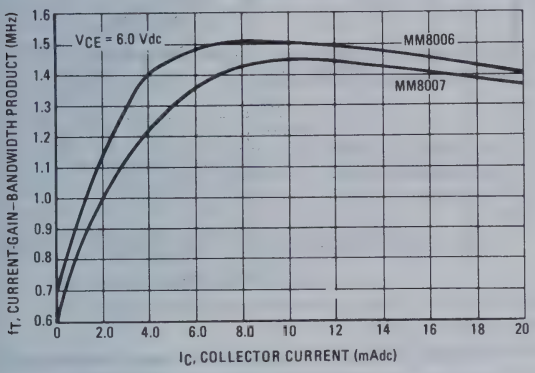


FIGURE 4 – S_{11} AND S_{22}

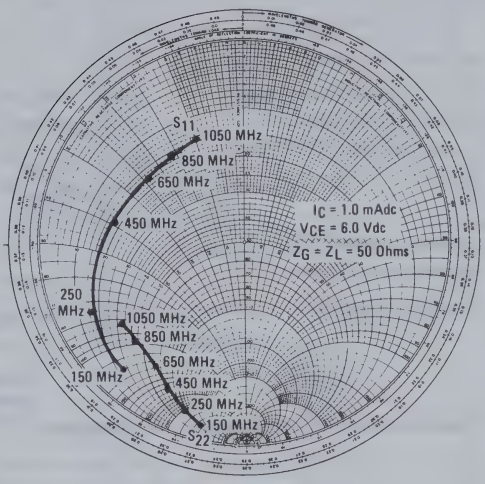


FIGURE 5 – S_{12}

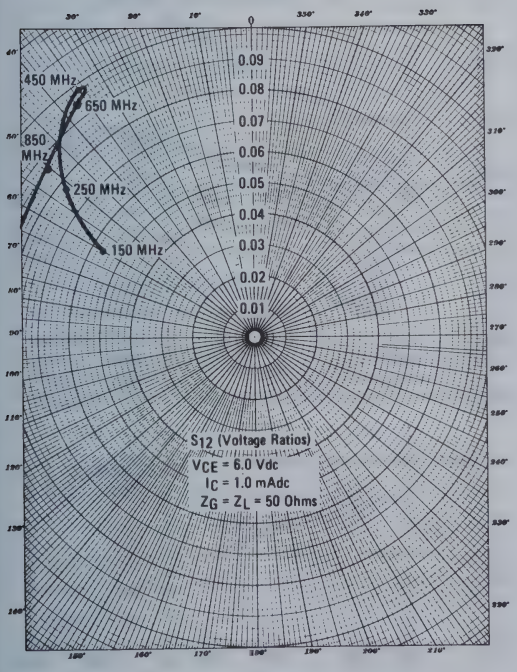


FIGURE 6 – S_{21}

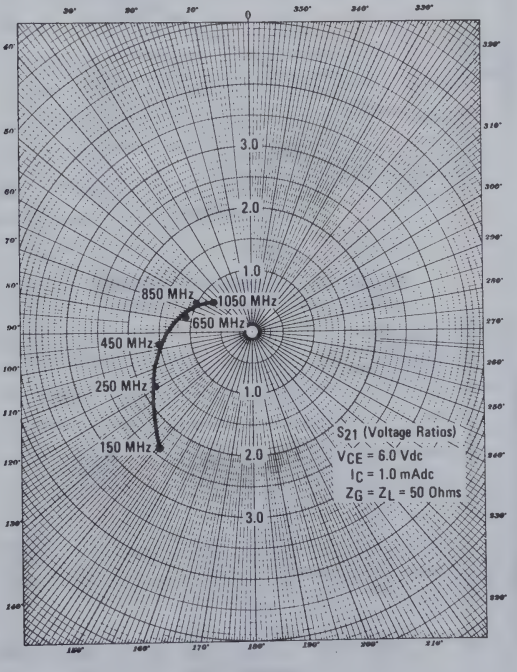


FIGURE 7 – NOISE FIGURE versus FREQUENCY

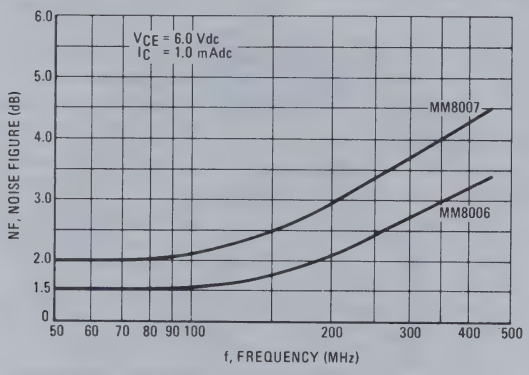


FIGURE 8 – POWER GAIN versus FREQUENCY

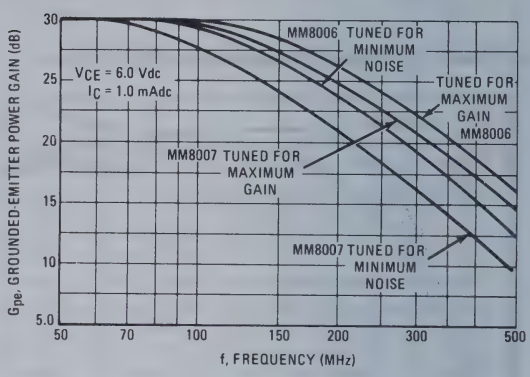


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

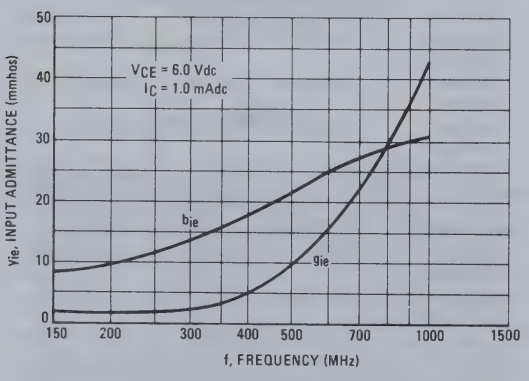


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

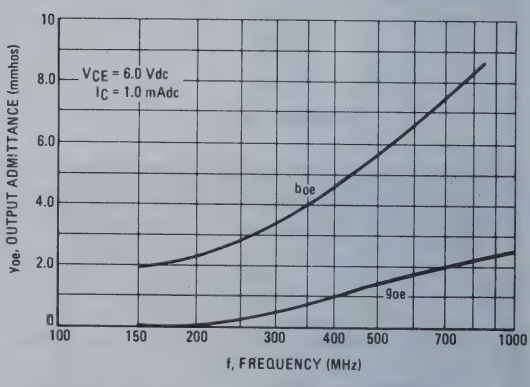


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

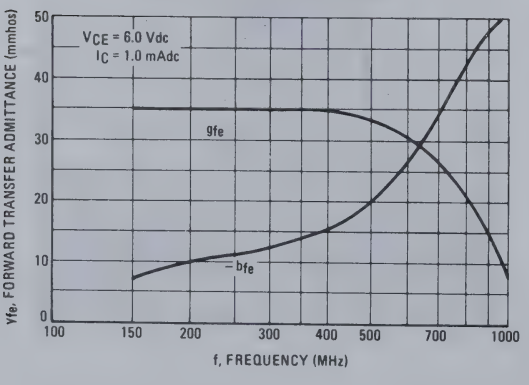
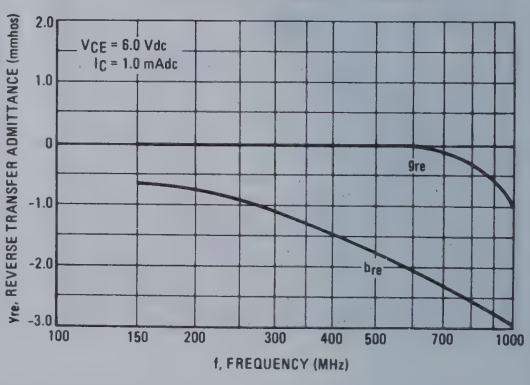


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



MM8008 (SILICON)
MM8010
MM8011

NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for oscillator, frequency multiplier, and UHF amplifier applications in military and industrial equipment.

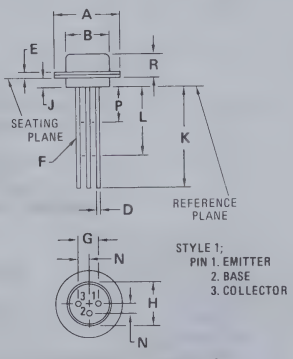
- High Power Output (Oscillator) —
  P_{out} = 300 mW (Min) @ f = 2.0 GHz (MM8008)
  200 mW (Min) @ f = 2.0 GHz (MM8010)
  100 mW (Min) @ f = 2.0 GHz (MM8011)
- High Current-Gain—Bandwidth Product —
  f_T = 1000 MHz (Typ) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications —
  P_{out} (Oscillator) = 550 mW (Typ) @ f = 1.68 GHz (MM8008)
  450 mW (Typ) @ f = 1.68 GHz (MM8010)
  300 mW (Typ) @ f = 1.68 GHz (MM8011)
- Wide Flange Case for Easy Mounting in Cavity Circuits
- Multiple Emitter Construction for Excellent High-Frequency Performance

NPN SILICON RF POWER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.13	8.89	0.320	0.350
B	5.08	5.46	0.200	0.215
D	0.407	0.533	0.016	0.021
E	–	0.76	–	0.030
F	0.407	0.482	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	4.07	4.32	0.160	0.170
J	1.15	1.52	0.045	0.060
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050
R	2.67	3.42	0.105	0.135

All JEDEC dimensions and notes apply

CASE 23
TO-107

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	1100	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.3	3.0	pF
FUNCTIONAL TEST					
Oscillator Power Output (Figure 1) (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 2.0 GHz) MM8008	P_{out}	0.3	–	–	Watt
MM8010		0.2	–	–	
MM8011		0.1	–	–	

FIGURE 1 – 2.0 GHz OSCILLATOR TEST CIRCUIT

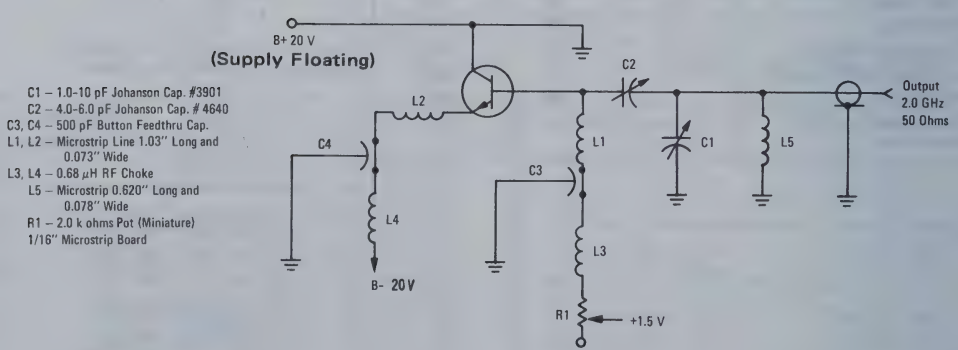


FIGURE 2 – TOP VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

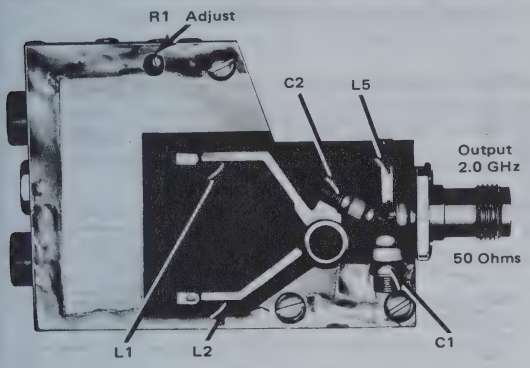


FIGURE 3 – SIDE VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

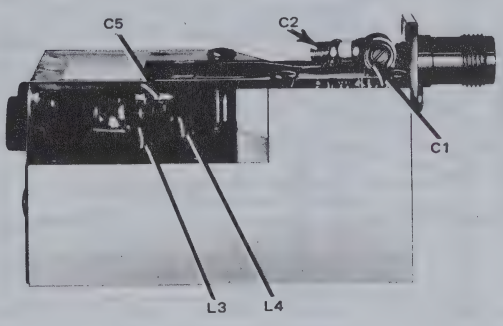


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

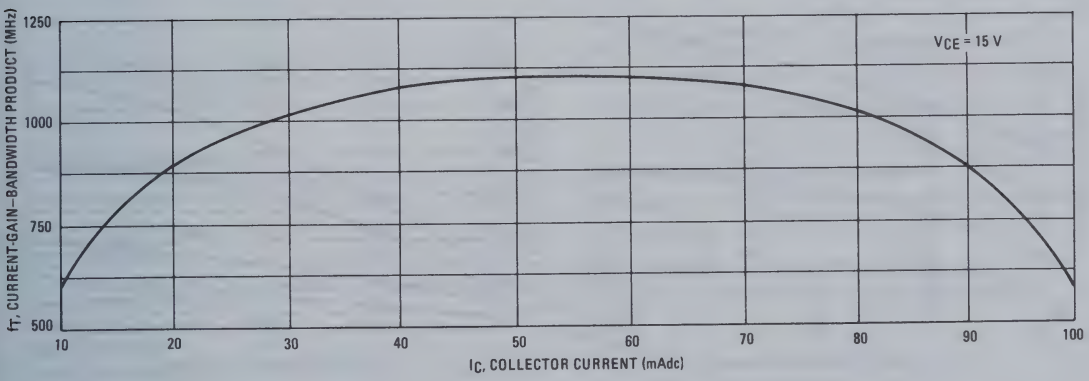
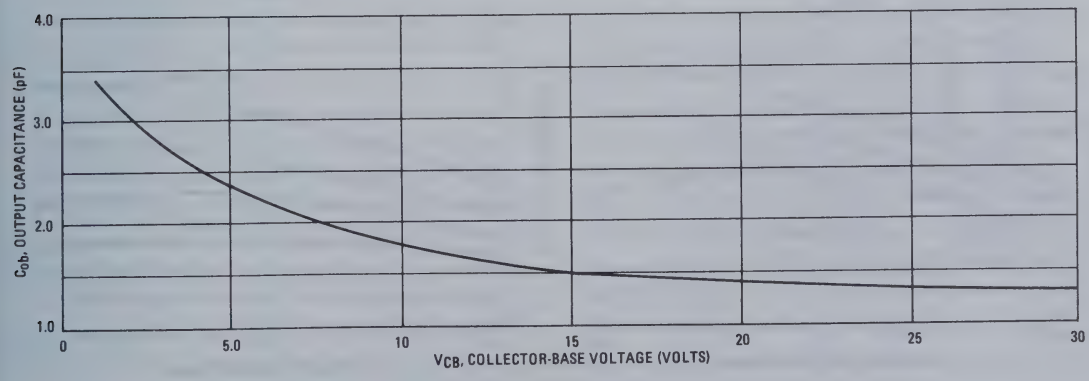


FIGURE 5 – OUTPUT CAPACITANCE versus VOLTAGE



OSCILLATOR OUTPUT POWER versus CURRENT
(SEE FIGURE 1 FOR TEST CIRCUIT)

FIGURE 6 – f = 2.0 GHz
MM8008

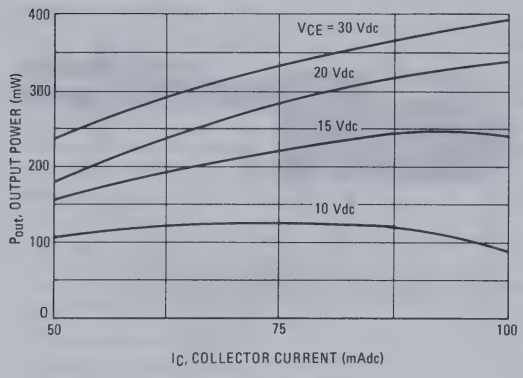
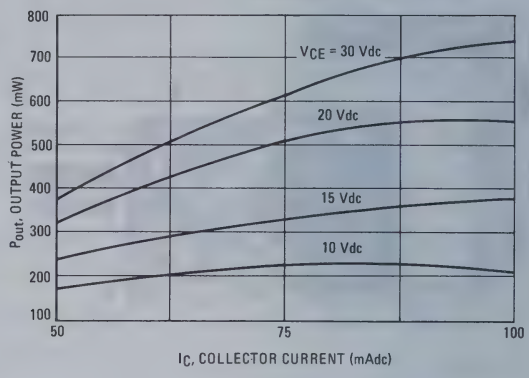
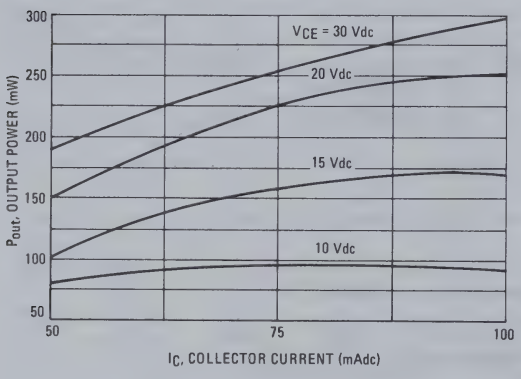


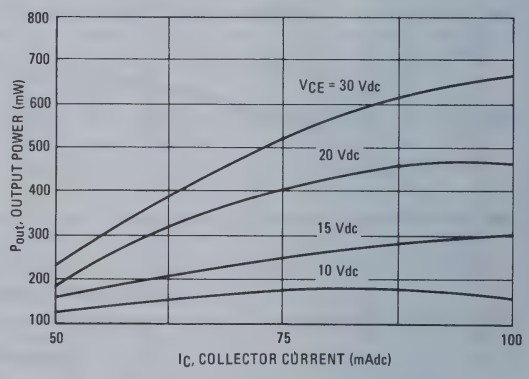
FIGURE 7 – f = 1.68 GHz
MM8008



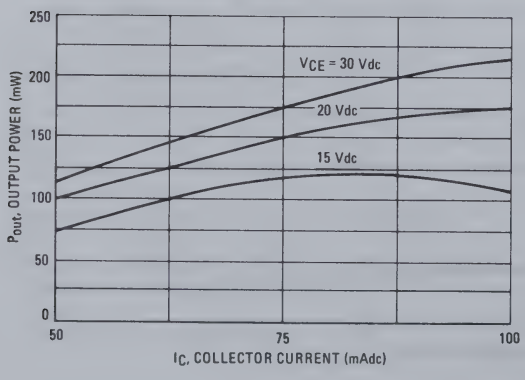
MM8010



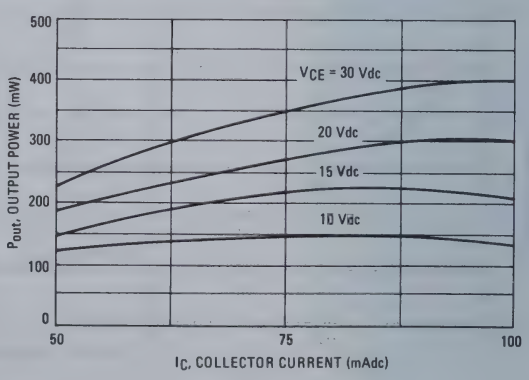
MM8010



MM8011



MM8011



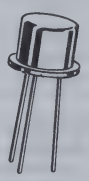
MM8009 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

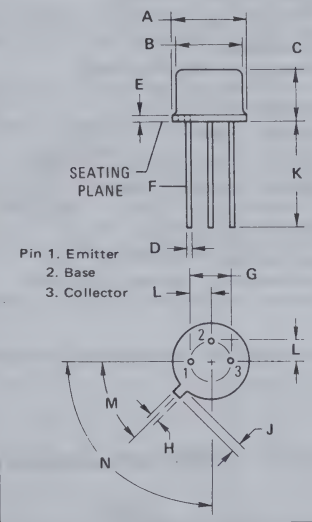
- High Output Power — P_{out} = 0.9 Watt (Min) @ f = 1.0 GHz
- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Min) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications — P_{out} (Oscillator) = 300 mW (Typ) @ f = 1.68 GHz

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



Pin 1. Emitter
2. Base
3. Collector

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.350	0.370	8.890	9.400
B	0.315	0.335	8.000	8.510
C	0.240	0.260	6.100	6.600
D	0.016	0.019	0.406	0.483
E	0.009	0.125	0.229	3.180
F	0.015	0.019	0.406	0.483
G	0.190	0.210	4.830	5.330
H	0.028	0.034	0.711	0.864
J	0.029	0.040	0.737	1.020
K	0.500	–	12.700	–
L	0.100 TP		2.540 TP	
M	45° NOM		45° NOM	
N	90° NOM		90° NOM	

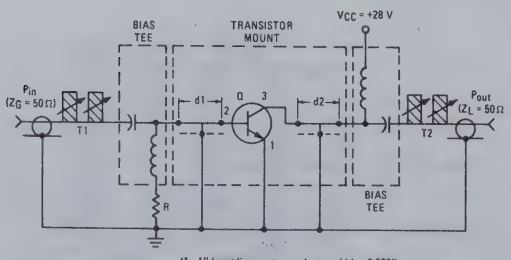
All JEDEC dimensions and notes apply

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

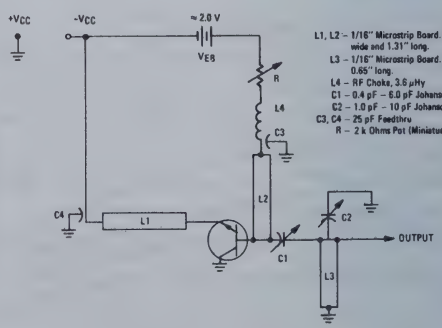
	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0)	I_{CES}	–	–	10	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	1000	–	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.8	3.0	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	0.9	–	–	Watt
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	–	0.3	–	Watt
Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	–	–	%

FIGURE 1 – 1.0 GHz POWER AMPLIFIER TEST CIRCUIT



d1: 1" Input line, center conductor width = 0.280"
d2: 1" Output line, center conductor width = 0.125"
Q: 2N5108
R: 3.9 ohms
T1, T2: Microlab Double Stub Tuner, or Equivalent
Bias Tee: Microlab 08N, or Equivalent
Transistor Mount: 1/32" Microstrip board

FIGURE 2 – 1.68 GHz POWER OSCILLATOR TEST CIRCUIT



L1, L2 – 1/16" Microstrip Board. Lines are 0.16" wide and 1.31" long.
L3 – 1/16" Microstrip Board. 0.16" wide and 0.65" long.
L4 – RF Choke, 3.6 μHy
C1 – 0.4 pF – 6.0 pF Johanson 4640
C2 – 1.0 pF – 10 pF Johanson 4355
C3, C4 – 25 pF Feedthru
R – 2 k Ohms Pot (Miniature)

FIGURE 3 – POWER OUTPUT versus POWER INPUT

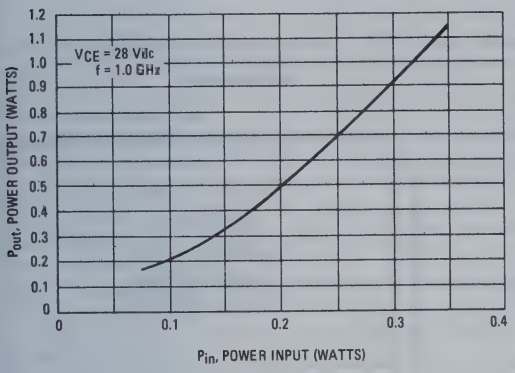


FIGURE 4 – POWER OUTPUT versus FREQUENCY

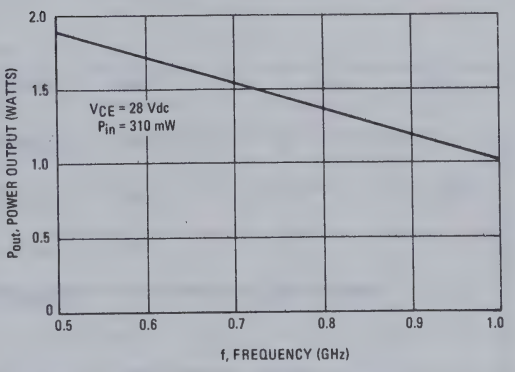


FIGURE 5 – POWER OUTPUT versus VOLTAGE

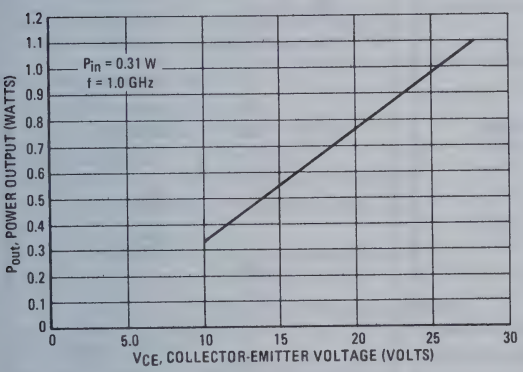


FIGURE 6 – OSCILLATOR POWER OUTPUT versus CURRENT

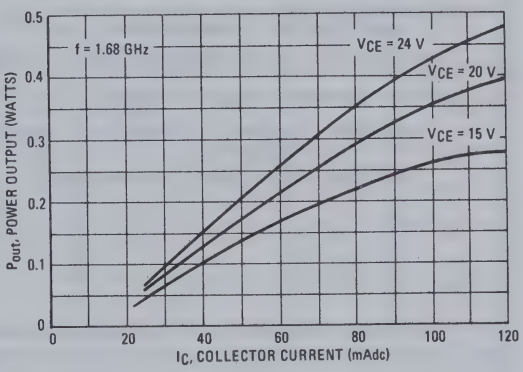


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

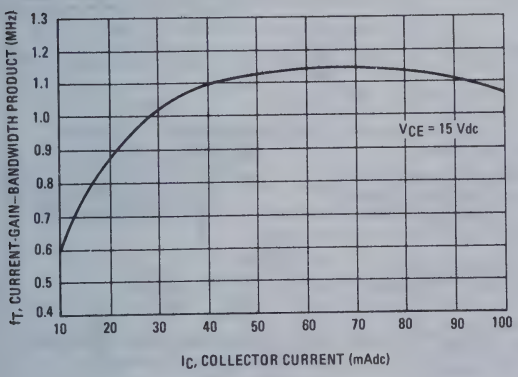
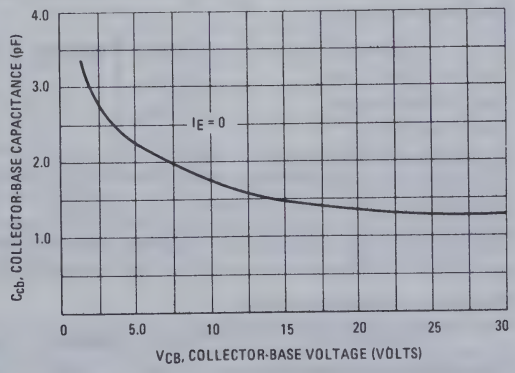


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE



MM8010
MM8011

For Specifications, See MM8008 Data.

MMCM918 (SILICON)
MMT918

NPN SILICON ANNULAR TRANSISTORS

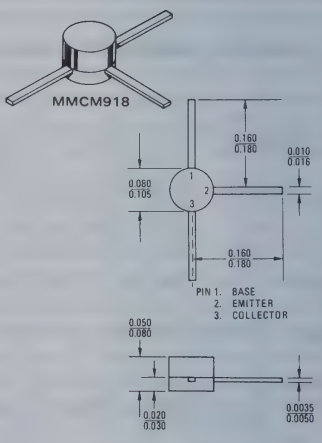
. . . designed for VHF and UHF amplifier, mixer and oscillator applications.

- Space Saving Micro-Miniature Packages
- High Current-Gain–Bandwidth Product – f_T = 600 MHz (Min)
- Low Capacitance – C_{ob} = 1.7 pF (Max)
- MMT918 – One-Piece, Injection-Molded Package for High Reliability

  MMCM918 – Ceramic Package for Hermeticity

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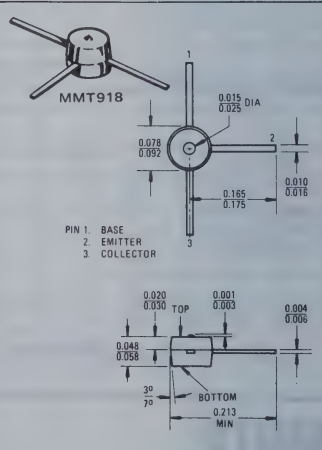
CASE 176 (1)

MAXIMUM RATINGS

Rating	Symbol	MMCM918	MMT918	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM918	MMT918	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.87	0.49	°C/mW



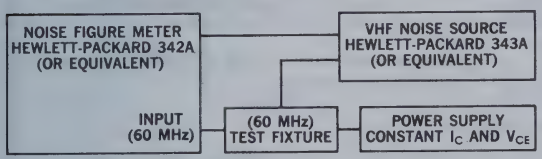
CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 100 MHz)	f_T	600	–	–	MHz
Output Capacitance	C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)		–	–	1.7	
(V_{CB} = 0, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)		–	–	3.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)	C_{ib}	–	–	2.0	pF
Noise Figure (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	NF	–	–	6.0	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (Figure 2) (V_{CC} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	–	23	–	dB
Power Output (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_{out}	–	60	–	mW
Collector Efficiency (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	–	50	–	%

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NOISE FIGURE TEST BLOCK DIAGRAM



The test fixture shall consist of a 60 MHz tuned amplifier and suitable biasing circuits. It should be constructed utilizing good very-high-frequency design techniques.

The effective source susceptance should be tuned for each device being tested to obtain minimum noise figure. Note that because the HP 343A has a 50-ohm output resistance, a suitable impedance transformer must be used to obtain an effective source conductance of 2.5 mmho at the transistor with minimum losses.

FIGURE 2 – NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT

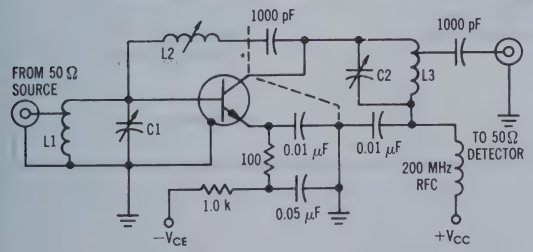
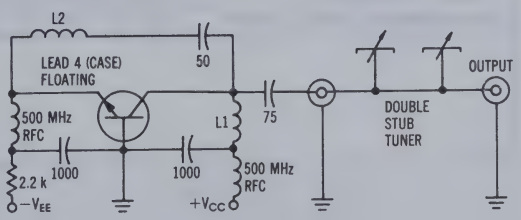


FIGURE 3 – 500 MHz OSCILLATOR TEST CIRCUIT



MMCM930, MMT930 (SILICON)
MMCM2484, MMT2484

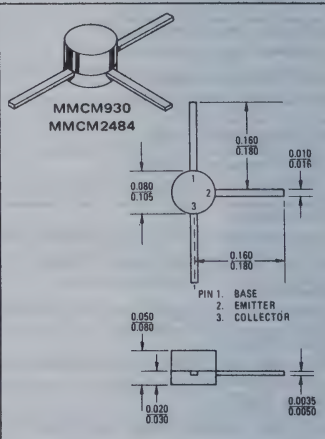
NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-level, low noise amplifier applications.

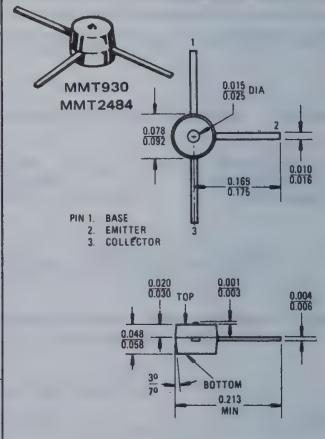
- MMT Plastic Micro–T
- MMCM Hermetic Ceramic Micro–T
- Space Saving Micro-Miniature Packages
- High Breakdown Voltages –
  $V_{CEO(sus)}$ = 45 Vdc (Min) @ I_C = 10 mAdc (MMT930, MMCM930)
  = 60 Vdc (Min) @ I_C = 10 mAdc (MMT2484, MMCM2484)
- High DC Current Gain –
  h_{FE} = 800 (Max) @ I_C = 10 mAdc
- MMT930, MMT2484 – One-Piece, Injection-Molded Unibloc Package for High Reliability
  MMCM930, MMCM2484 – Ceramic Package for Hermeticity

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NPN SILICON AMPLIFIER TRANSISTORS



CASE 176 (1)



CASE 28 (1)

MAXIMUM RATINGS

Rating	Symbol	MMCM930 MMT930	MMCM2484 MMT2484	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		MMCM930 MMCM2484	MMT930 MMT2484	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM930 MMCM2484	MMT930 MMT2484	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.87	0.49	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	MMCM930,MMT930	$V_{CEO(sus)}$	45	–	Vdc
	MMCM2484,MMT2484		60	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	–	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		100	–	
	MMCM2484,MMT2484		175	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		125	–	
	MMCM2484,MMT2484		200	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		150	–	
	MMCM2484,MMT2484		250	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	All Types		–	800	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.5	0.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		f_T	60	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0)		C_{ob}	–	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)		C_{ib}	–	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to kHz, Power Bandwidth = 15.7 kHz)	MMCM2484,MMT2484	NF	–	3.0	dB

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMCM2222 (SILICON)
MMT2222

NPN SILICON ANNULAR TRANSISTORS

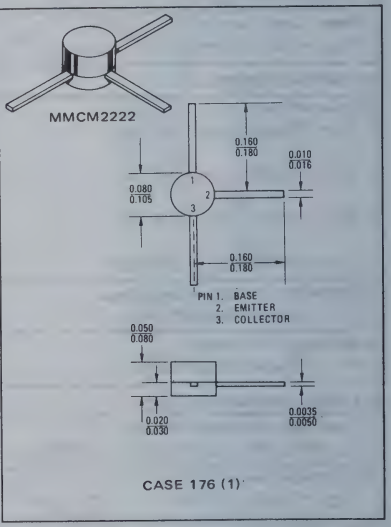
. . . designed for high-speed switching circuits and DC to VHF amplifier applications.

- Space Saving Micro-Miniature Packages
- High DC Current Gain Range — I_C Specified from 1.0 mA to 300 mA
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- MMT2222 — One-Piece, Injection-Molded Unibloc Package for High Reliability

  MMCM2222 — Ceramic Package for Hermeticity

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NPN SILICON SWITCHING TRANSISTORS



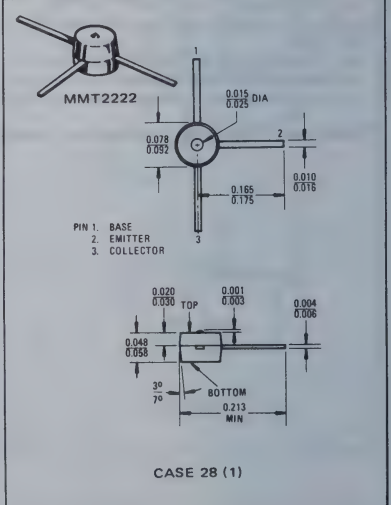
CASE 176 (1)

MAXIMUM RATINGS

Rating	Symbol	MMCM2222	MMT2222	Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM2222	MMT2222	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.87	0.490	°C/mW



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)		30	–	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.9	1.6	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	1.4	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	16	–	ns
Turn-Off Time (Figure 2)	t_{off}	–	160	–	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

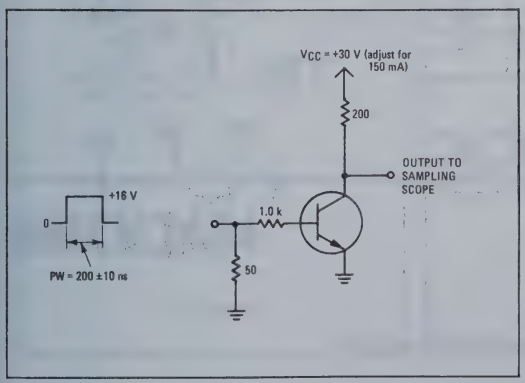
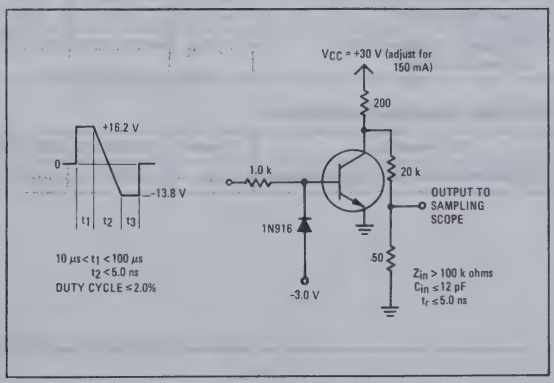


FIGURE 2 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



MMCM2369 (SILICON)
MMT2369

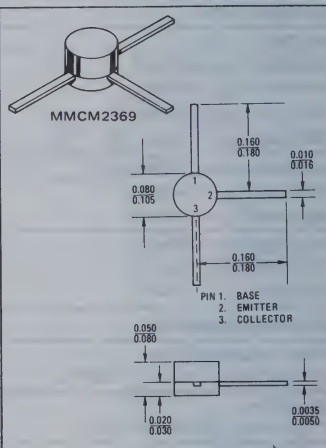
NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed, low current switching applications where high-density packaging is required.

- Space Saving Micro-Miniature Packages
- Ideal for Thick Film Digital Circuit Applications
- MMT2369 – One-Piece, Injection-Molded Unibloc Package for High Reliability
  MMCM2369 – Ceramic Package for Hermeticity

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NPN SILICON SWITCHING TRANSISTORS



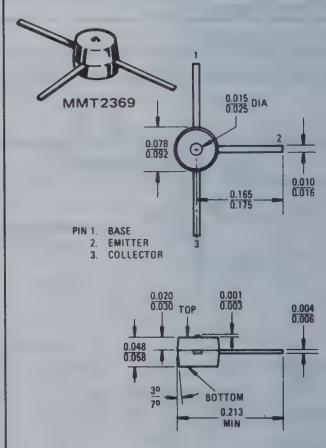
CASE 176 (1)

MAXIMUM RATINGS

Rating	Symbol	MMCM2369	MMT2369	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 1.14	225 2.05	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM2369	MMT2369	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.87	0.49	$^oC/mW$



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	120	–
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		20	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	18	ns
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	$t_{s(\tau s)}$	–	13	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – t_{on} CIRCUIT

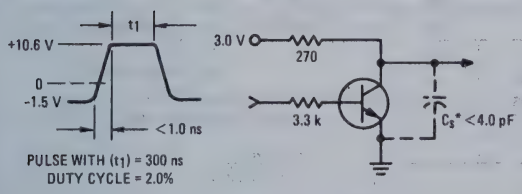
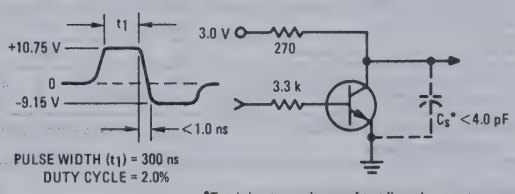


FIGURE 2 – t_{off} CIRCUIT



*Total shunt capacitance of test jig and connectors.

MMCM2484

For Specifications, See MMCM930 Data.

MMCM2907 (SILICON)
MMT2907

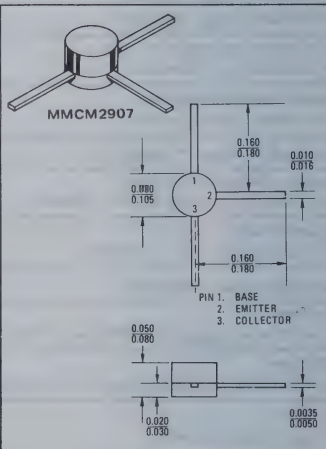
PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications, where high-density packaging is required.

- Space Saving Micro-Miniature Packages
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- High Voltage Rating — BV_{CEO} = 40 Vdc (Min)
- DC Current Gain Specified from 1.0 mAdc to 300 mAdc
- MMT2907 — One-Piece, Injection-Molded Unibloc Package for High Reliability

  MMCM2907 — Ceramic Package for Hermeticity

MICRO-T
PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS



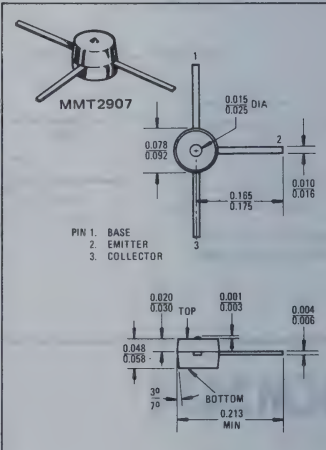
CASE 176 (1)

MAXIMUM RATINGS

Rating	Symbol	MMCM2907	MMT2907	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM2907	MMT2907	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.87	0.49	°C/mW



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)		30	–	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	–	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)(1)		–	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	–	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	260	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	4.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	20	–	ns
Turn-Off Time (Figure 2)	t_{off}	–	150	–	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

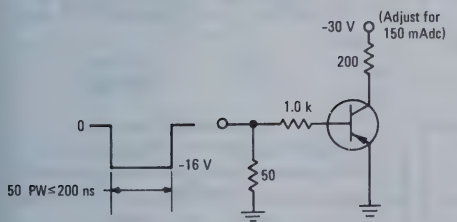
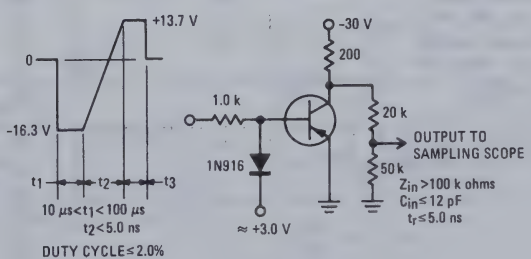


FIGURE 2 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



MMD70 (SILICON)

SILICON EPITAXIAL SWITCHING DIODE

. . . designed for general-purpose, high-speed switching applications.

- High Breakdown Voltage –
  $V_{(BR)}$ = 50 Vdc (Min) @ $I_{(BR)}$ = 100 μAdc
- Space-Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to MMD6050

MICRO-MINIATURE
SILICON EPITAXIAL
SWITCHING DIODE



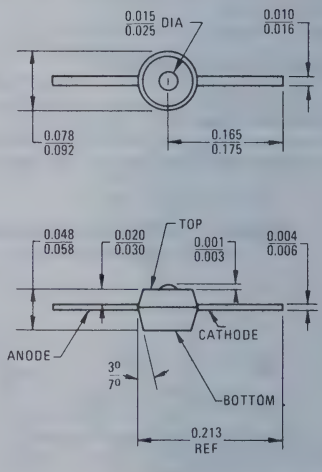
ACTUAL SIZE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	50	–	Vdc
Reverse Current (V_R = 30 Vdc)	I_R	–	100	nAdc
Forward Voltage (I_F = 100 mAdc)	V_F	0.75	1.2	Vdc
Capacitance (V_R = 0)	C	–	2.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 15 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	15	ns



Cathode identified by color dot on top of package.
CASE 166

MMD6050 (SILICON)
MMD6100
MMD6150
MMD7000

Silicon epitaxial micro-miniature switching diodes — single, series and dual diodes designed for general-purpose, high-speed switching applications.



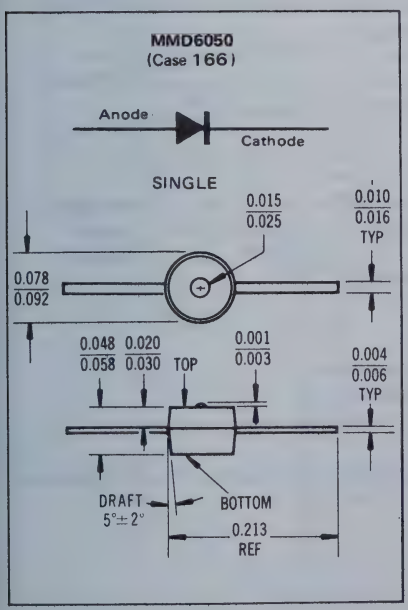
MMD6050 — Case 166

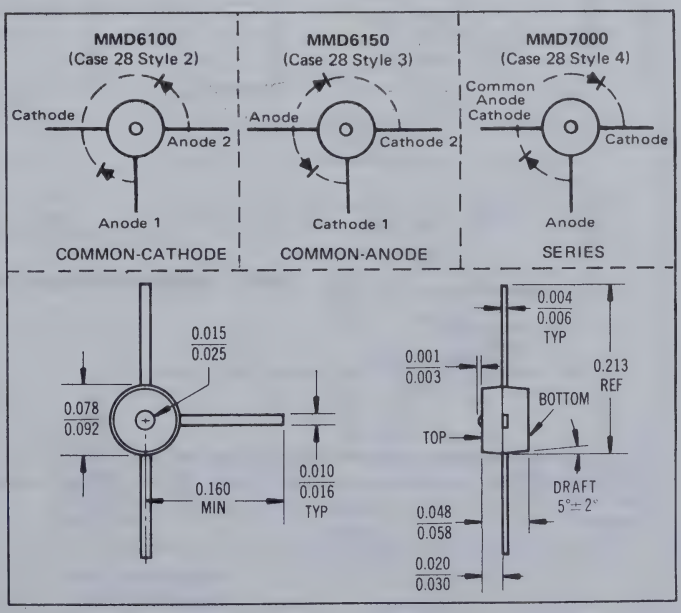


MMD6100 — Case 28 (2)
MMD6150 — Case 28 (3)
MMD7000 — Case 28 (4)

MAXIMUM RATINGS (each diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C





MMD6050, MMD6100, MMD6150, MMD7000 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	-	-	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	-	-	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc) (I_F = 100 mAdc)	V_F	0.55 0.85	- -	0.7 1.1	Vdc
Capacitance (V_R = 0)	C	-	1.2	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc)	t_{rr}	-	1.5	5.0	ns

FIGURE 1 — FORWARD CHARACTERISTICS

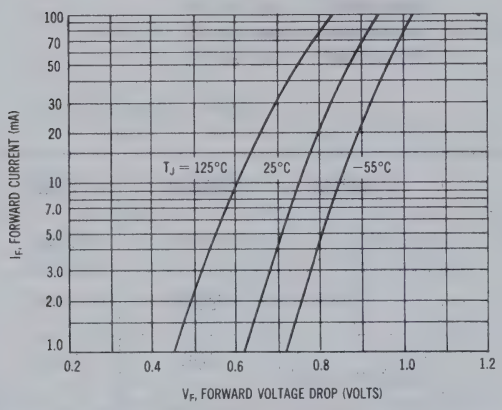


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

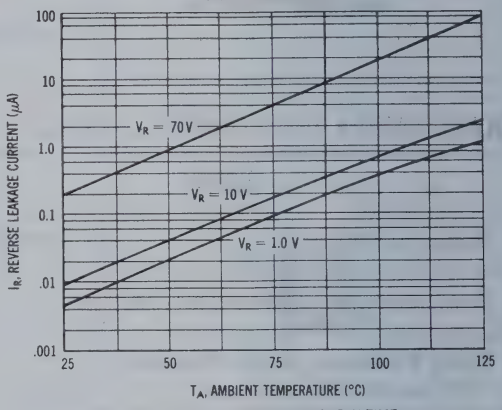


FIGURE 3 — CAPACITANCE

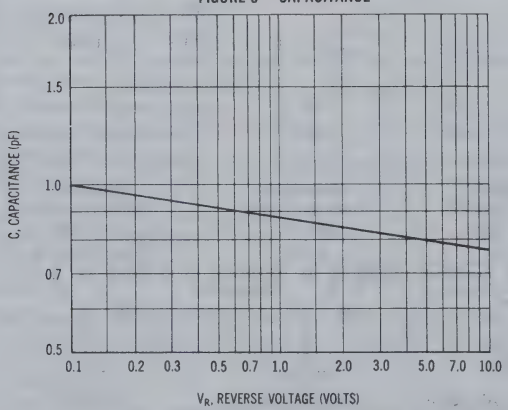


FIGURE 4 — REVERSE RECOVERY TIME

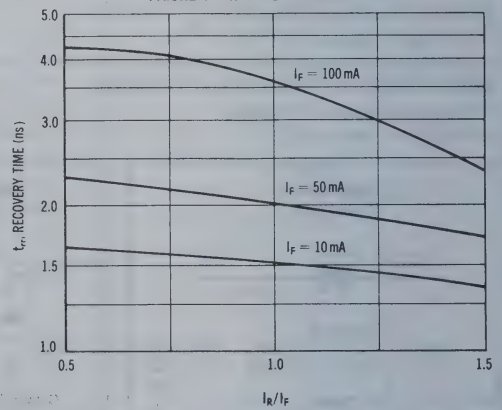
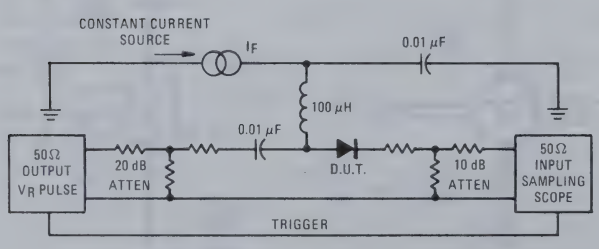
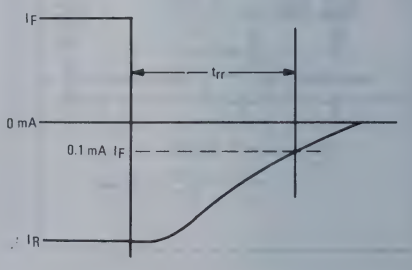


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



V_R Pulse Rise Time ≤ 0.25 ns
Scope Rise Time ≤ 0.35 ns



MMD7001 (SILICON)

SILICON EPITAXIAL DUAL SWITCHING DIODE

. . . designed for general purpose, high-speed switching applications.

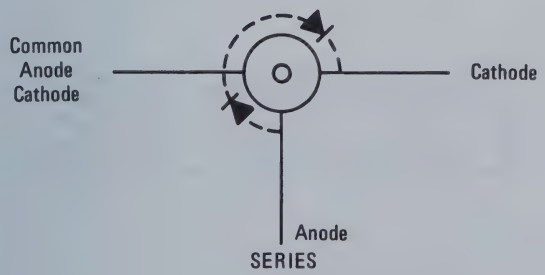
- High Breakdown Voltage –
  $V_{(BR)}$ = 45 Vdc (Min) @ $I_{(BR)}$ = 10 μAdc
- Fast Reverse Recovery Time –
  t_{rr} = 3.2 ns (Typ) @ $I_F = I_R$ = 10 mAdc
- Low Capacitance –
  C = 2.5 pF (Typ) @ V_R = 0
- Space-Saving Micro-Miniature Package

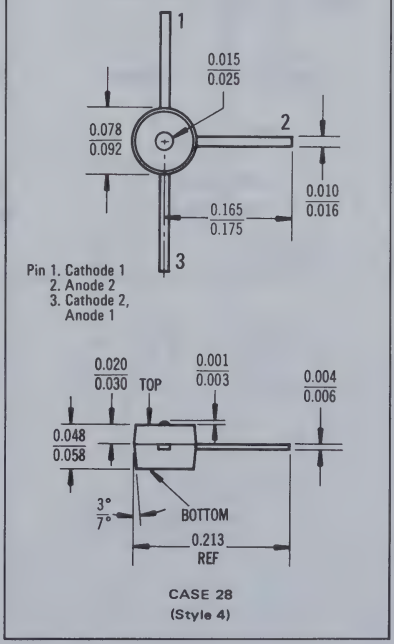
MICRO-MINIATURE SILICON EPITAXIAL DUAL SWITCHING DIODE



MAXIMUM RATINGS (each diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	45	Vdc
Recurrent Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	600	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C



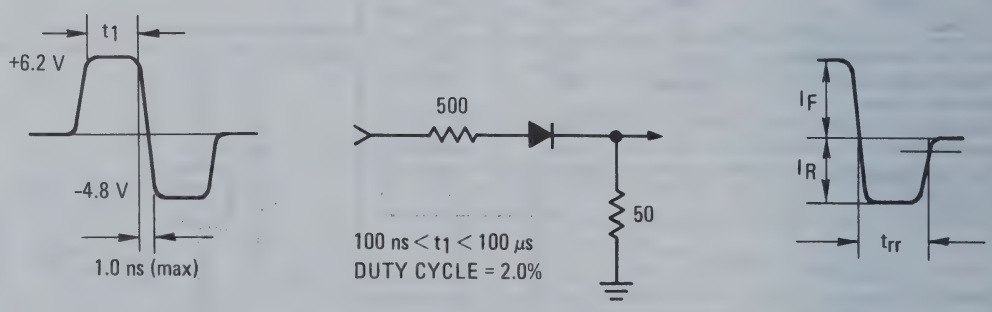


CASE 28
(Style 4)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 10 μAdc)	$V_{(BR)}$	45	–	–	Vdc
Reverse Current (V_R = 30 Vdc)	I_R	–	–	0.1	μAdc
Forward Voltage	V_F				Vdc
(I_F = 100 mAdc)		0.75	–	0.9	
(I_F = 300 mAdc)		–	–	1.05	
(I_F = 500 mAdc)		–	–	1.15	
Capacitance (V_R = 0)	C	–	2.5	3.5	pF
Total Control Charge (I_F = 10 mAdc)	Q_S	–	–	50	pC
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	3.2	–	ns

FIGURE 1 – RECOVERY TIME EQUIVALENT TEST CIRCUIT



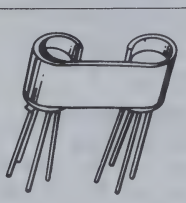
MMF1 thru MMF6 (SILICON)

MATCHED SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . consists of two individual 2N3823 device types which have been carefully matched for critical applications, such as differential amplifier service. Each matched pair is packaged in a metal clip for pair identity and each device is marked with the basic 2N3823 type number and a date code for further identification in the event of removal from the clip.

- Guaranteed Temperature Tracking – (0°C to 100°C)
  $\Delta|V_{GS_1} - V_{GS_2}|/\Delta T$ = 10 μV/°C – MMF1, MMF2
  25 μV/°C – MMF3, MMF4
  50 μV/°C – MMF5, MMF6
- Excellent Gate-Source Voltage Match –
  $|V_{GS_1} - V_{GS_2}|$ = 5.0 mVdc (Max)
- Tight I_{DSS} Match –
  ΔI_{DSS} = 5.0% (Max) – MMF1, MMF2
- Low Noise Figure – NF = 2.5 dB (Max) @ 100 MHz (Each Device)

MATCHED JUNCTION FIELD-EFFECT TRANSISTORS TYPE A



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

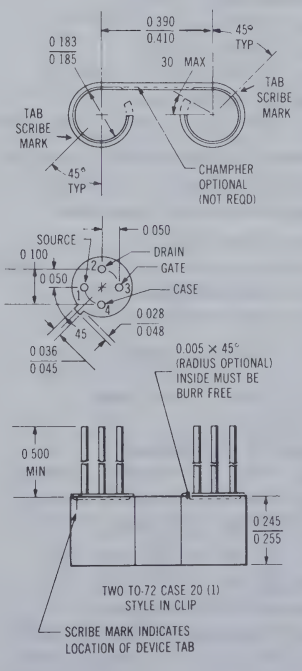


TABLE I – DIFFERENTIAL GATE-SOURCE VOLTAGE CHANGE WITH TEMPERATURE

Conditions:
V_{DG} = 15 Vdc
MMF1, MMF3, MMF5 – I_D = 300 μAdc
MMF2, MMF4, MMF6 – I_D = 750 μAdc

Device Type	0°C to +25°C	+25°C to +100°C
MMF1, MMF2	0.250 mVdc	0.750 mVdc
MMF3, MMF4	0.625 mVdc	1.875 mVdc
MMF5, MMF6	1.250 mVdc	3.750 mVdc

ELECTRICAL CHARACTERISTICS (each 2N3823) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Voltage (I_D = 0.4 mAdc, V_{DS} = 15 Vdc)		V_{GS}	1.0	–	7.5	Vdc
Gate-Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)		$V_{GS(off)}$	0.2	–	8.0	Vdc
Gate Reverse Current		I_{GSS}				nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0)			–	–	0.5	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			–	–	500	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)		I_{DSS}	4.0	–	20	mAdc
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance						μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1)		$\lvert y_{fs}\rvert$	3500	–	6500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{fs})$	3200	–	–	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	–	–	800	μmhos
Output Conductance						μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1)		$\lvert y_{os}\rvert$	–	–	35	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	–	–	200	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	–	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	–	2.0	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 k ohm, f = 100 MHz)		NF	–	–	2.5	dB
MATCHING CHARACTERISTICS (MMF1 thru MMF6, See Note 2)						
Zero-Gate-Voltage Drain Current Ratio (I_{DSS_1} is the lower of the two values)		$\frac{I_{DSS_1}}{I_{DSS_2}}$				–
(V_{DS} = 15 Vdc, V_{GS} = 0)	MMF1,MMF2		0.95	–	1.0	
	MMF3,MMF4,MMF5,MMF6		0.90	–	1.0	
Forward Transfer Admittance Ratio ($\lvert y_{fs}\rvert_1$ is the lower of the two values)		$\frac{\lvert y_{fs}\rvert_1}{\lvert y_{fs}\rvert_2}$				–
(V_{DG} = 15 Vdc, I_D = 300 μAdc)	MMF1		0.98	–	1.0	
	MMF3,MMF5		0.95	–	1.0	
(V_{DG} = 15 Vdc, I_D = 750 μAdc)	MMF2		0.98	–	1.0	
	MMF4,MMF6		0.95	–	1.0	
Differential Output Conductance		$\lvert\lvert y_{os}\rvert_1 - \lvert y_{os}\rvert_2\rvert$				μmho
(V_{DG} = 15 Vdc, I_D = 750 μAdc, f = 1.0 kHz)	MMF1,MMF3,MMF5		–	–	1.0	
(V_{DG} = 15 Vdc, I_D = 300 μAdc, f = 1.0 kHz)	MMF2,MMF4,MMF6		–	–	1.0	
Differential Gate-Source Voltage		$\lvert V_{GS_1} - V_{GS_2}\rvert$				mVdc
(V_{DG} = 15 Vdc, I_D = 300 μAdc)	MMF1,MMF3,MMF5		–	–	5.0	
(V_{DG} = 15 Vdc, I_D = 750 μAdc)	MMF2,MMF4,MMF6		–	–	5.0	
Differential Gate Reverse Current		$\lvert I_{G_1} - I_{G_2}\rvert$				nAdc
(V_{DG} = 15 Vdc, I_D = 300 μAdc, T_A = 100°C)			–	1.0	10	
(V_{DG} = 15 Vdc, I_D = 750 μAdc, T_A = 100°C)			–	1.0	10	
Differential Gate-Source Voltage Change with Temperature		See TABLE I				

(1)Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤10%.

(2)Matching characteristics apply only to pairs of devices originally packaged as a matched pair.

MMT70 (SILICON)

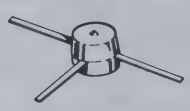
NPN SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON
AMPLIFIER
TRANSISTOR



MAXIMUM RATINGS

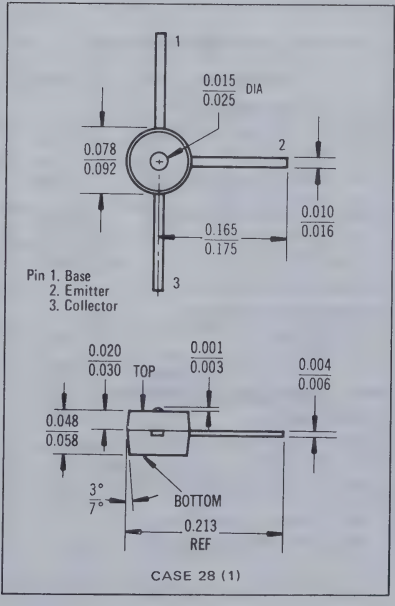
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	150	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	–	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	NF	–	1.0	–	dB



CASE 28 (1)

MMT71 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Low Noise Figure — NF = 1.5 dB (Typ) @ f = 1.0 kHz
- Low Output Capacitance — C_{ob} = 2.0 pF (Typ) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N5086

MICRO-MINIATURE

PNP SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

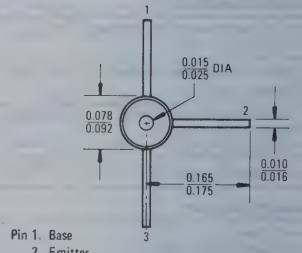
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

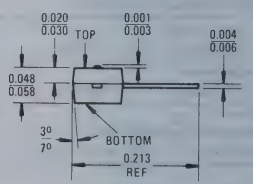
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	150	–	–	–
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	–	10	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, (R_S = 3.0 kohms, f = 1.0 kHz)	NF	–	1.5	–	dB



Pin 1. Base
2. Emitter
3. Collector



CASE 28 (1)

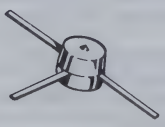
MMT72 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE NPN SILICON SWITCHING TRANSISTOR

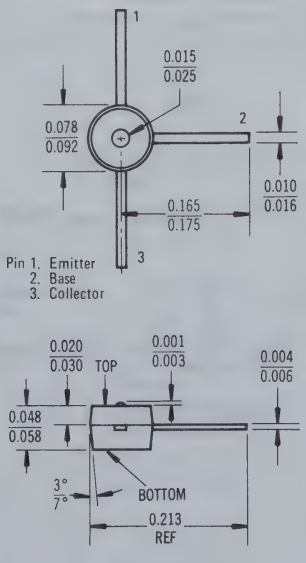


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Emitter Voltage	V_{CES}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	$^oC/mW$

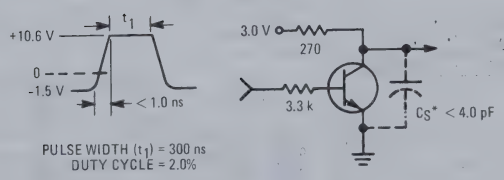


CASE 28(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

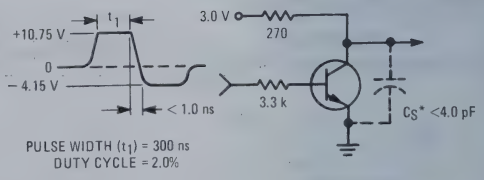
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	30	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	20	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	30	ns

FIGURE 1 – t_{on} CIRCUIT



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 – t_{off} CIRCUIT



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

*Total shunt capacitance of test jig and connectors.

MMT73 (SILICON)

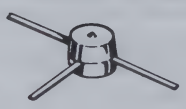
PNP SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N3546

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR

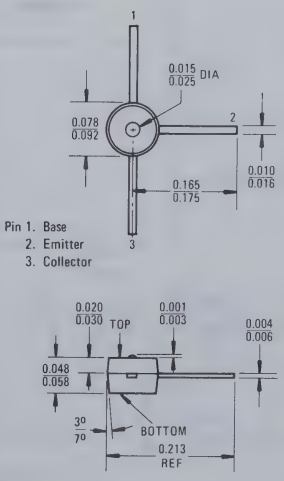


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Emitter Voltage	V_{CES}	8.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



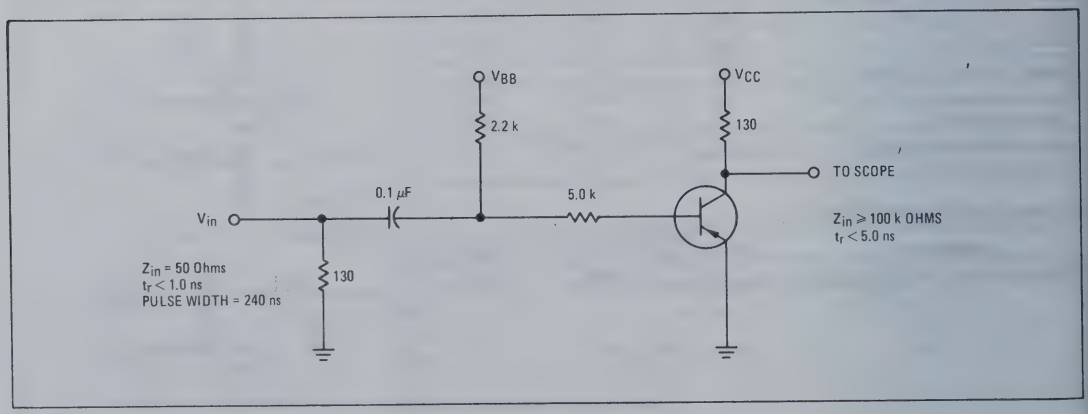
Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	8.0	–	Vdc
Emitter-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 20	– –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	–	30	ns
Turn-Off Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	–	30	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



	V_{in} Vdc	V_{BB} Vdc	V_{CC} Vdc	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	Gnd	-1.5	10	1.0	1.0
t_{off}	+10	-8.0	-1.5	10	1.0	1.0

MMT74 (SILICON)

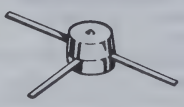
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator and mixer applications.

- High Current-Gain—Bandwidth Product —
  f_T = 1000 MHz (Typ) @ I_C = 4.0 mAdc
- Low Collector — Base Capacitance
  C_{cb} = 1.0 pF (Typ) @ V_{CB} = 10 Vdc
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON RF AMPLIFIER TRANSISTOR

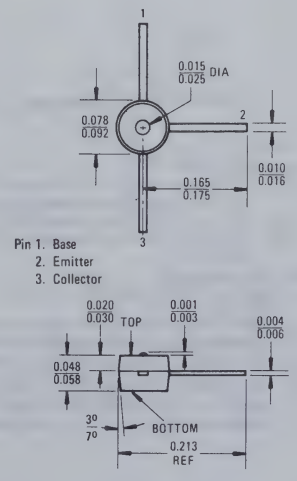


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	1000	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.0	3.0	pF
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF	–	4.0	–	dB
FUNCTIONAL TEST					
Common Emitter Amplifier Power Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	–	14	–	dB

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN

Capacitance values in pF

L1, L2 – Silver plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2" turn #16 AWG wire, located 1/4" from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

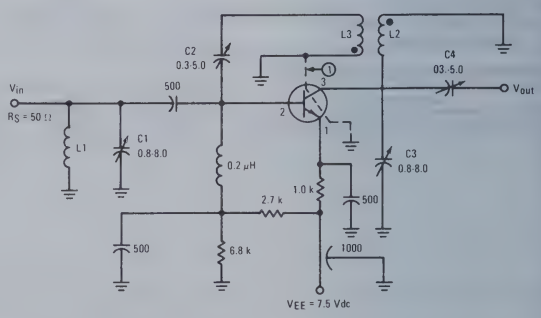
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.



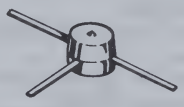
MMT75-PNP (SILICON)
MMT76-NPN

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications and for complementary circuitry where high-density packaging is required.

- Current Gain Specified in Two Ranges for Design Flexibility
- Low Output Capacitance –
  C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to NPN-2N3903, and PNP-2N3905

MICRO-MINIATURE COMPLEMENTARY SILICON SWITCHING AND AMPLIFIER TRANSISTORS

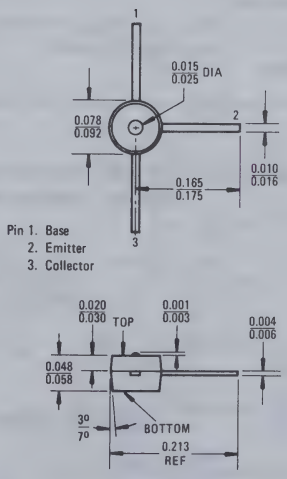


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



Pin 1. Base
2. Emitter
3. Collector

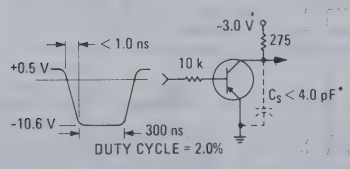
CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	Both		50	–	400	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MMT75		20	–	–	
	MMT76		30	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	–	5.0	pF
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms,	MMT75		–	1.0	–	
BW = 10 Hz to 15.7 kHz)	MMT76		–	3.0	–	
SWITCHING CHARACTERISTICS						
Delay Time						
(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	MMT75	t_d	–	25	–	ns
	MMT76		–	24	–	
Rise Time						
	MMT75	t_r	–	18	–	ns
	MMT76		–	13	–	
Storage Time						
(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MMT75	t_s	–	140	–	ns
	MMT76		–	125	–	
Fall Time						
	MMT75	t_f	–	15	–	ns
	MMT76		–	11	–	

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 – MMT75 –PNP



STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

FIGURE 2 – MMT75–PNP

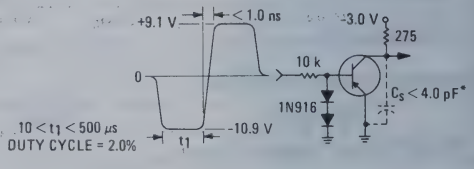


FIGURE 3 – MMT76 –NPN

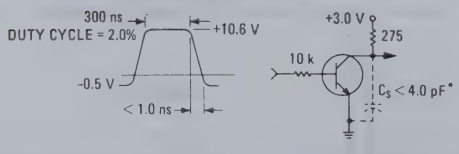
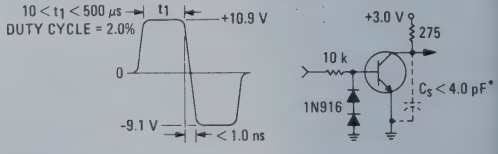


FIGURE 4 – MMT76 –NPN



*Total shunt capacitance of test jig and connectors

MMT806 (SILICON)

NPN SILICON ANNULAR TRANSISTOR MICRO POWER SERIES

. . . designed for high-speed, low-power switching circuits.

- DC Current Gain @ Ultra Low Current –
  h_{FE} = 150 (Typ) @ I_C = 1.0 μAdc
- High Current-Gain – Bandwidth Product –
  f_T = 2100 MHz (Typ) @ I_C = 1.0 mAdc
- Low Capacitances –
  C_{ob} = 0.6 pF (Max) @ V_{CB} = 1.0 Vdc
  C_{ib} = 0.35 pF (Max) @ V_{BE} = 1.0 Vdc
- Space-Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Complement to PNP Type MMT808

MICRO-MINIATURE NPN SILICON SWITCHING TRANSISTOR

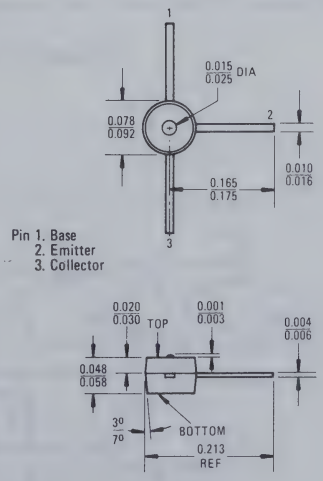


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/W



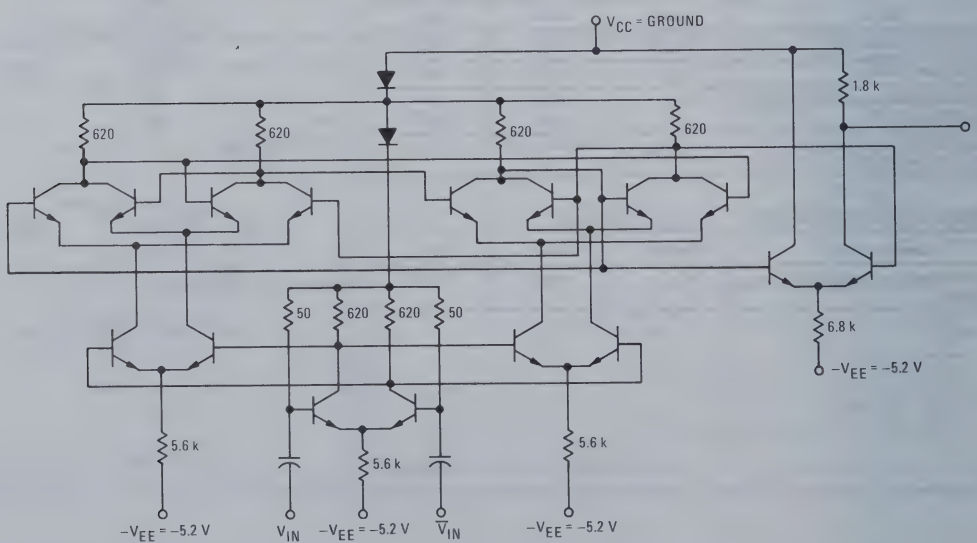
Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 1.0 Vdc) (I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 20 50	 150 175	 – –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 μAdc, I_B = 0.2 μAdc) (I_C = 100 μAdc, I_B = 10 μAdc)	$V_{CE(sat)}$	 – –	 58 55	 – 100	mVdc
Base-Emitter Saturation Voltage (I_C = 1.0 μAdc, I_B = 0.2 μAdc) (I_C = 100 μAdc, I_B = 10 μAdc)	$V_{BE(sat)}$	 – –	 0.58 0.69	 0.70 0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 1.0 μAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (I_C = 10 μAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	 – – 1200	 20 120 2100	 – – –	MHz
Output Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.33	0.6	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	0.2	0.35	pF

FIGURE 1 – 250 MHz TYPICAL OPERATING FREQUENCY CIRCUIT
(At Total P_D Unloaded of 10 mW)



MMT807 (SILICON)

NPN SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-frequency, low-power amplifier applications.

- DC Current Gain @ Ultra Low Current —
  h_{FE} = 125 (Typ) @ I_C = 10 μAdc
- High Current-Gain—Bandwidth Product —
  f_T = 2100 MHz (Typ) @ I_C = 1.0 mAdc
- Low Capacitances —
  C_{ob} = 0.55 pF (Max) @ V_{CB} = 0.5 Vdc
  C_{ib} = 0.45 pF (Max) @ V_{BE} = 0
- Typical Power Gain = 18 dB @ I_C = 100 μAdc
- Typical Noise Figure = 2.0 dB @ I_C = 100 μAdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Complement to PNP Type MMT809

MICRO-MINIATURE
NPN SILICON
AMPLIFIER
TRANSISTOR

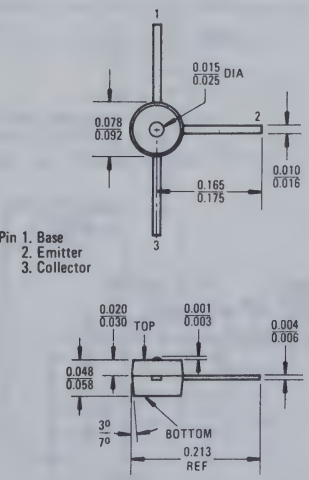


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/W



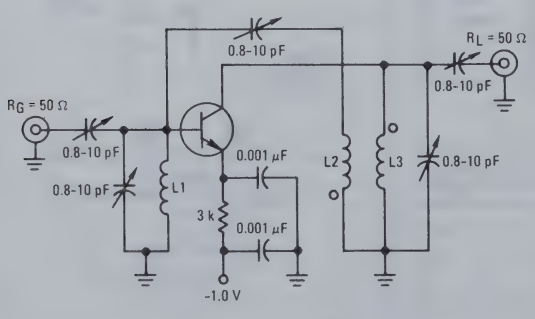
Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

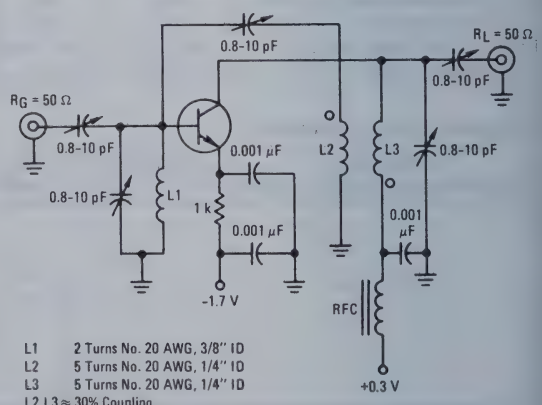
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 20 25	 125 150	 – –	–
Collector-Emitter Saturation Voltage (I_C = 10 μAdc, I_B = 1.0 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)	$V_{CE(sat)}$	 – –	 71 56	 100 125	mVdc
Base-Emitter Saturation Voltage (I_C = 10 μAdc, I_B = 1.0 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)	$V_{BE(sat)}$	 – –	 0.62 0.77	 0.70 0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	1200	2100	–	MHz
Output Capacitance (V_{CB} = 0.5 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.34	0.55	pF
Input Capacitance (V_{BE} = 0, I_C = 0, f = 100 MHz)	C_{ib}	–	0.27	0.45	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)	NF	 – –	 2.0 2.5	 – –	dB
Power Gain (I_C = 100 μAdc, V_{CE} = 0.7 Vdc, f = 200 MHz) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (Figure 2)	G_{pe}	 – –	 18 23	 – –	dB

FIGURE 1 – 200 MHz TEST CIRCUIT POWER GAIN-NOISE FIGURE (NEUTRALIZED, I_C = 100 μAdc)



L1 3 Turns No. 20 AWG, 1/4" ID
L2 4 Turns No. 20 AWG, 1/4" ID
L3 5 Turns No. 20 AWG, 1/4" ID
L2,L3 ≈ 30% Coupling

FIGURE 2 – 200 MHz TEST CIRCUIT POWER GAIN-NOISE FIGURE (NEUTRALIZED, I_C = 1.0 mAdc)



L1 2 Turns No. 20 AWG, 3/8" ID
L2 5 Turns No. 20 AWG, 1/4" ID
L3 5 Turns No. 20 AWG, 1/4" ID
L2,L3 ≈ 30% Coupling

MMT808 (SILICON)

PNP SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-speed, low-power switching circuits.

- DC Current Gain @ Ultra Low Current –
  h_{FE} = 65 (Typ) @ I_C = 1.0 μAdc
- High Current-Gain – Bandwidth Product –
  f_T = 2500 MHz (Typ) @ I_C = 1.0 mAdc
- Low Capacitances –
  C_{ob} = 0.8 pF (Max) @ V_{CB} = 1.0 Vdc
  C_{ib} = 0.3 pF (Max) @ V_{BE} = 1.0 Vdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability
- Complement to NPN Type MMT806

MICRO-MINIATURE
PNP SILICON
TRANSISTOR

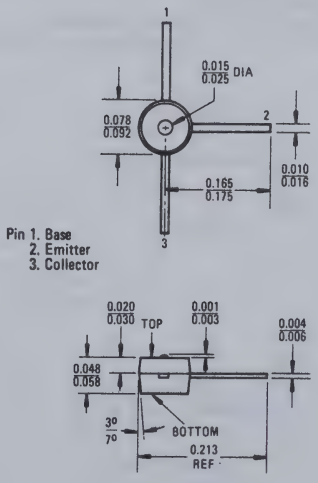


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/W



Pin 1. Base
2. Emitter
3. Collector

CASE 28(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	mVdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 1.0 μAdc, V_{CE} = 1.0 Vdc)		20	65	–	
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)		50	80	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
(I_C = 1.0 μAdc, I_B = 0.2 μAdc)		–	94	–	
(I_C = 100 μAdc, I_B = 10 μAdc)		–	74	100	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 1.0 μAdc, I_B = 0.2 μAdc)		–	0.58	0.7	
(I_C = 100 μAdc, I_B = 10 μAdc)		–	0.69	0.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product	f_T				MHz
(I_C = 1.0 μAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)		–	20	–	
(I_C = 10 μAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)		–	100	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)		1200	2500	–	
Output Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.42	0.8	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	0.2	0.3	pF

MMT809 (SILICON)

PNP SILICON ANNULAR TRANSISTOR MICRO POWER SERIES

. . . designed for high-frequency, low-power amplifier applications.

- DC Current Gain @ Ultra Low Current –
  h_{FE} = 70 (Typ) @ I_C = 10 μAdc
- Low Capacitances –
  C_{ob} = 0.8 pF (Max)
  C_{ib} = 0.5 pF (Max)
- Typical Power Gain = 17 dB @ I_C = 100 μAdc
- Typical Noise Figure = 2.6 dB @ I_C = 100 μAdc
- High Current-Gain–Bandwidth Product –
  f_T = 2500 MHz (Typ) @ I_C = 1.0 mAdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability
- Complement to NPN Type MMT807

MICRO-MINIATURE PNP SILICON AMPLIFIER TRANSISTOR

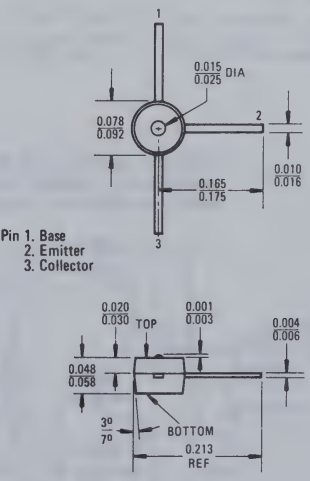


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/W



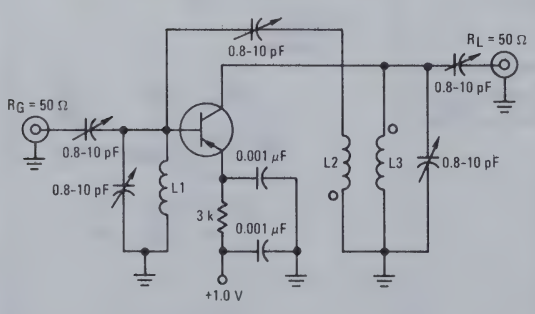
Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

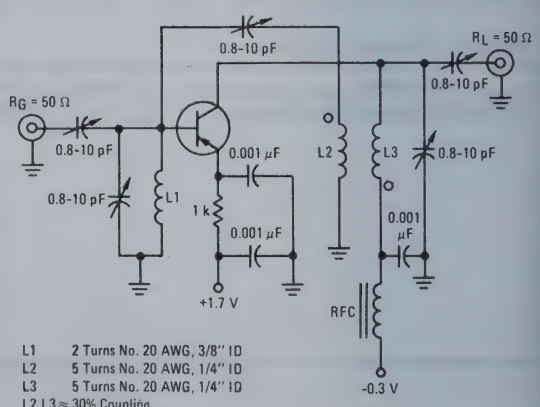
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 1.0 Vdc)		20	70	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		25	75	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	100	130	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	68	125	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	0.64	0.70	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	0.78	0.85	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	1200	2500	–	MHz
Output Capacitance (V_{CB} = 0.5 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.47	0.8	pF
Input Capacitance (V_{BE} = 0, I_C = 0, f = 100 MHz)	C_{ib}	–	0.34	0.5	pF
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1)		–	2.6	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)		–	3.0	–	
Power Gain	G_{pe}				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1)		–	17	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)		–	23	–	

FIGURE 1 – 200 MHz TEST CIRCUIT
POWER GAIN – NOISE FIGURE
(NEUTRALIZED, I_C = 100 μAdc)



L1 3 Turns No. 20 AWG, 1/4" ID
L2 4 Turns No. 20 AWG, 1/4" ID
L3 5 Turns No. 20 AWG, 1/4" ID
L2,L3 ≈ 30% Coupling

FIGURE 2 – 200 MHz TEST CIRCUIT
POWER GAIN – NOISE FIGURE
(NEUTRALIZED, I_C = 1.0 mAdc)



L1 2 Turns No. 20 AWG, 3/8" ID
L2 5 Turns No. 20 AWG, 1/4" ID
L3 5 Turns No. 20 AWG, 1/4" ID
L2,L3 ≈ 30% Coupling

MMT918

For Specifications, See MMCM918 Data.

MMT930

MMT2484

For Specifications, See MMCM930 Data.

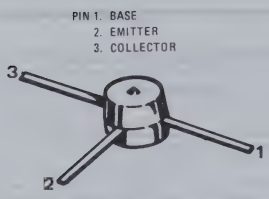
MMT2222

For Specifications, See MMCM2222 Data.

MMT2369

For Specifications, See MMCM2369 Data.

MMT2857 (SILICON)



CASE 28 (1)

NPN silicon annular micro-miniature transistor designed for high-gain, low-noise amplifier, oscillator and mixer applications.

MAXIMUM RATINGS

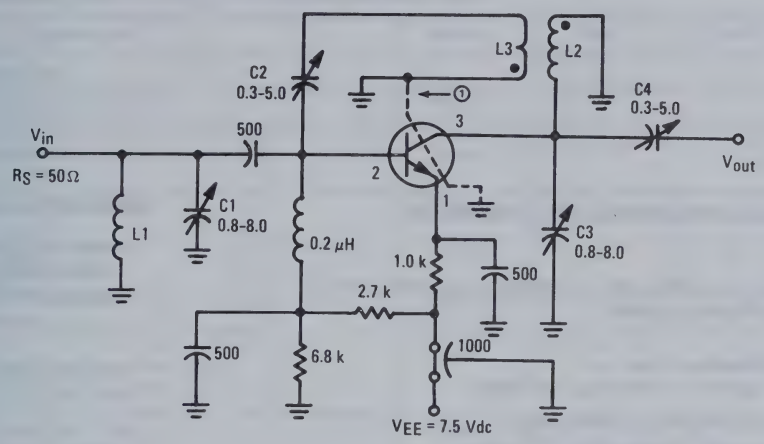
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and case grounded unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	f_T	1,000	1,300	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz) (Emitter and Case Guarded)	C_{cb}	-	0.5	1.0	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	-	8.0	-	ps
Noise Figure* (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF*	-	3.8	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	-	18	-	dB

*Measured in circuit of Figure 1 with no connections for input circuit losses or post amplifier contribution.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

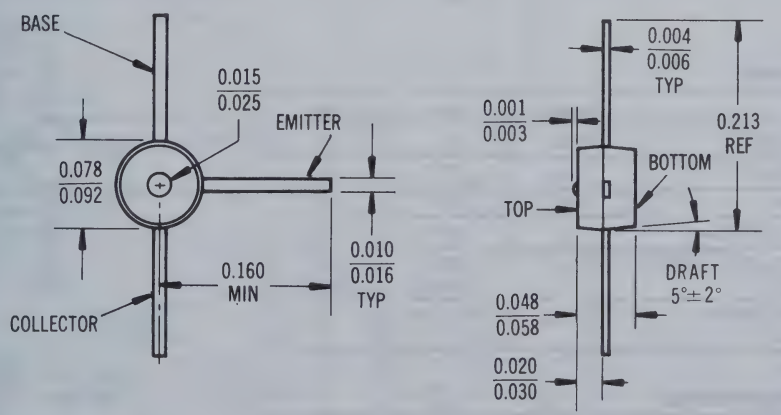
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

OUTLINE DIMENSIONS



CASE 28 (1)

MMT2907

For Specifications, See MMC2907 Data.

MMT3014 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

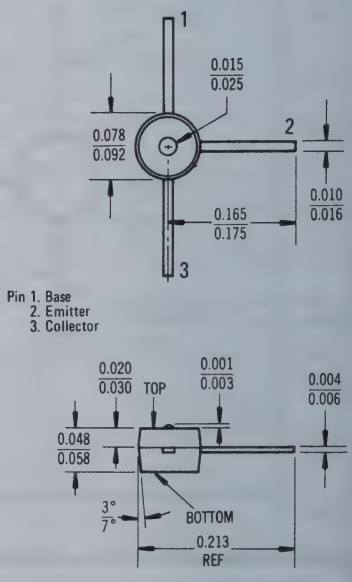
. . . designed for high-speed, saturated switching applications where high-density packaging is required.

- High-Speed Switching Times –
  $t_{on} + t_{off}$ = 41 ns (Max) @ I_C = 30 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.22 Vdc (Max) @ I_C = 30 mAdc
- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON SWITCHING TRANSISTOR





CASE 28 (1)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

MMT3014 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	50 25	200 –	–
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	–	0.22	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.70	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	–	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	8.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	16	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 3.0 mAdc)	t_{off}	–	25	ns
Charge Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_s	–	18	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

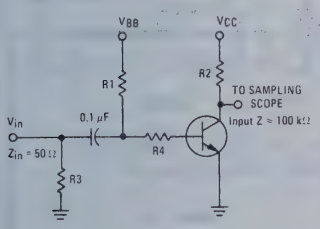
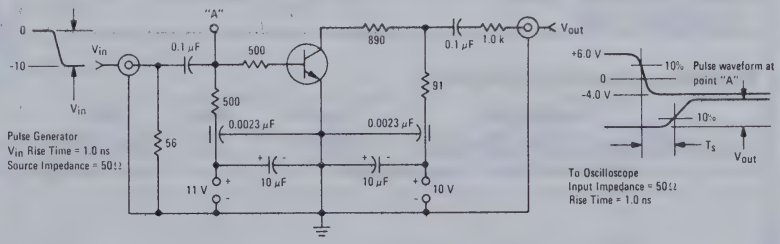


FIGURE 2 – CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



Vin Rise Time less than 1.0 ns, PW = 300 ns, Duty Cycle = 2.0%

SWITCHING TEST CIRCUIT VALUES								INPUT PULSE		
Test	V_{in}	V_{BB}	V_{CC}	R1	R2	R3	R4	t_r	t_f	Pulse Width
	VOLTS			OHMS				ns		
t_{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	–	>200
t_{off}	-13	7.0	2.0							

MMT3546 (SILICON)

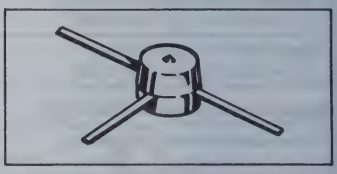
PNP SILICON ANNULAR TRANSISTOR

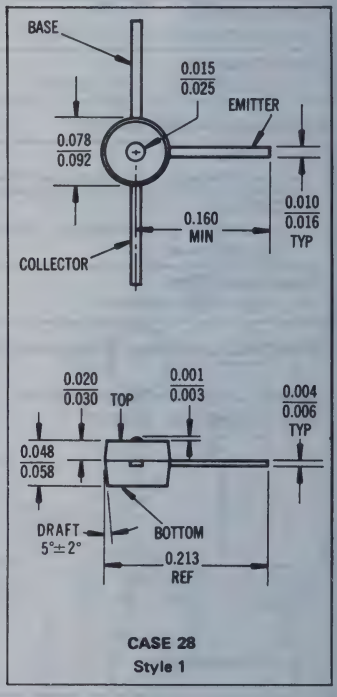
. . . designed for high-speed, low-level switching applications, where high-density packaging is required.

- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- Total Switching Time = 60 ns @ I_C = 50 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR





CASE 28
Style 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	250	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

MMT3546 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	-	-
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.15	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.9	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.6	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 3.0 Vdc, V_{BE} = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)	t_d	-	10	ns
Rise Time	t_r	-	15	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_s	-	20	ns
Fall Time	t_f	-	15	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

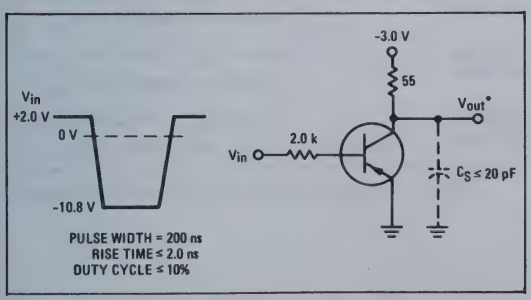
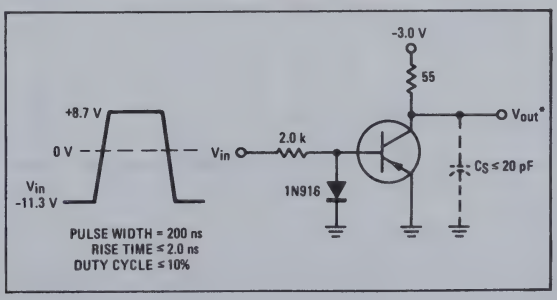
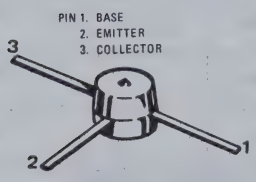


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*OSCILLOSCOPE RISE TIME ≤ 1.0 ns

MMT3798 (SILICON)
MMT3799



CASE 28 (1)

PNP silicon annular micro-miniature transistors designed for low-level, low-noise amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MMT3798		75	-	-	
	MMT3799		150	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMT3798		150	-	450	
	MMT3799		300	-	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMT3798		150	-	-	
	MMT3799		300	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMT3798		125	-	-	
	MMT3799		250	-	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	-	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	-	-	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	MMT3798		40	120	-	
	MMT3799		40	150	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	8.0	pF
Input Impedance		h_{ie}				k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798		-	8.0	-	
	MMT3799		-	16	-	
Voltage Feedback Ratio		h_{re}				X 10-4
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798		-	2.0	-	
	MMT3799		-	4.0	-	
Small-Signal Current Gain		h_{fe}				-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798		-	275	-	
	MMT3799		-	475	-	
Output Admittance		h_{oe}				μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798		-	18	-	
	MMT3799		-	30	-	
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MMT3798		-	4.0	-	
R_S = 3.0 k ohms, f = 100 Hz)	MMT3799		-	2.5	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MMT3798		-	1.5	-	
R_S = 3.0 k ohms, f = 1.0 kHz)	MMT3799		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MMT3798		-	1.0	-	
R_S = 3.0 k ohms, f = 10 kHz)	MMT3799		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MMT3798		-	2.5	3.5	
R_S = 3.0 k ohms, BW = 10 Hz to 15.7 kHz)	MMT3799		-	1.5	2.5	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT3823 (SILICON)

MICRO-T
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

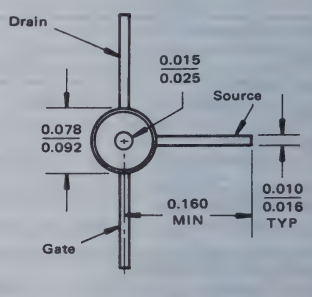
Depletion Mode (Type A) Field-Effect Transistor designed for RF amplifier and mixer applications where high density packaging is required.

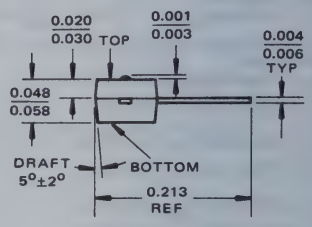
- Low Cross-Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure — 2.0 dB (Typ)
- Low Transfer and Input Capacitances
  C_{rss} = 1.0 pF (Typ); C_{iss} = 4.0 pF (Typ)
- Space Saving Micro-Miniature Package — Ideal for Thick Film Circuit Applications

MICRO-MINIATURE
JUNCTION
FIELD-EFFECT
TRANSISTOR

SYMMETRICAL
SILICON
N-CHANNEL
Type A







CASE 28
Style 5

Drain and Source may be Interchanged

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

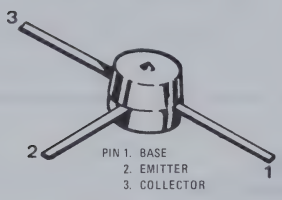
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-30	–	–	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)	I_{GSS}	–	–	-1.0	nAdc
Gate-Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	–	–	-8.0	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	-1.0	–	-8.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (1), (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	–	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (1)	$\|Y_{fs}\|$	3000	–	8000	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		–	4000	–	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	–	500	–	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (1)	$\|Y_{os}\|$	–	25	–	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(Y_{os})$	–	125	–	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.0	–	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	–	2.0	–	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

MMT3903 (SILICON)
MMT3904



CASE 28(1)

NPN silicon micro-miniature annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with type MMT3905 and MMT3906, where high-density packaging is required.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector-Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

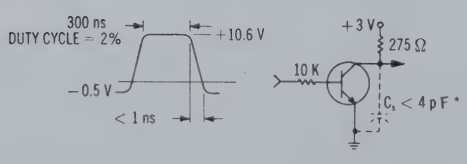
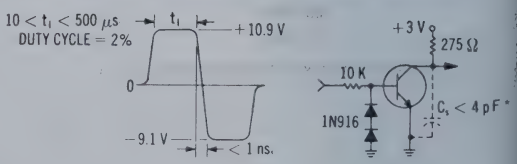


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



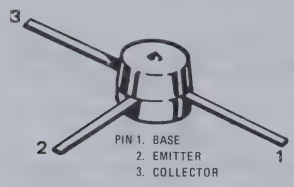
*Total shunt capacitance of test jig and connectors

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	MMT3903		20	-	-	
	MMT3904		40	-	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		35	-	-	
	MMT3904		70	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		50	-	150	
	MMT3904		100	-	300	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3903	f_T	250	-	-	MHz
	MMT3904		300	-	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	-	3.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	-	2.0	-	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3903	h_{fe}	-	100	-	-
	MMT3904		-	200	-	
Output Admittance (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	10	-	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms Noise Bandwidth — f = 10 Hz to 15.7 kHz)		NF	-	3.0	-	dB
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	t_d	-	24	-	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_r	-	13	-	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	t_s	-	125	-	ns
Fall Time	I_{B1} = I_{B2} = 1.0 mAdc)	t_f	-	11	-	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
For characteristic curves, see 2N3903/2N3904 Data.

MMT3905 (SILICON)
MMT3906



CASE 28 (1)

PNP silicon micro-miniature annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with types MMT3903 and MMT3904 where high-density packaging is required.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

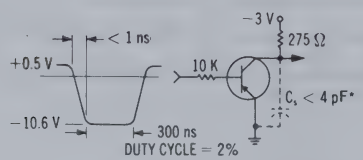
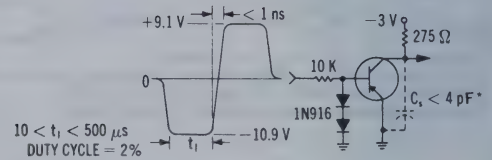


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	MMT3905 MMT3906	h_{FE}	30 60	- -	- -	-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3905 MMT3906		40 80	- -	- -	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3905 MMT3906		50 100	- -	150 300	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3905 MMT3906	f_T	200 250	- -	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	-	4.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	-	2.0	-	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3905 MMT3906	h_{fe}	- -	100 200	- -	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	15	-	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, Noise Bandwidth — f = 10 Hz to 15.7 kHz)		NF	-	1.0	-	dB
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	t_d	-	25	-	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_r	-	18	-	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	t_s	-	140	-	ns
Fall Time	I_{B1} = I_{B2} = 1.0 mAdc)	t_f	-	15		ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
For characteristic curves, see 2N3905/2N3906 Data.

MMT3960 (SILICON)

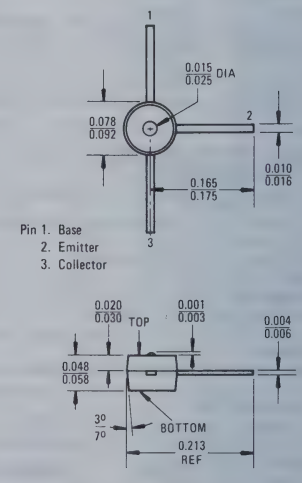
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain–Bandwidth Product –
  f_T = 2250 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance –
  C_{ob} = 1.3 pF (Typ) @ V_{CB} = 4.0 Vdc
  C_{ib} = 1.2 pF (Typ) @ V_{BE} = 0.5 Vdc
- Excellent Current-Mode Performance –
  t_r = 0.65 ns (Typ)
- Low Collector-Base Time Constant –
  $r_b'C_c$ = 15 ps (Typ) @ I_C = 30 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE
NPN SILICON HIGH-SPEED SWITCHING TRANSISTOR





CASE 28 (1)

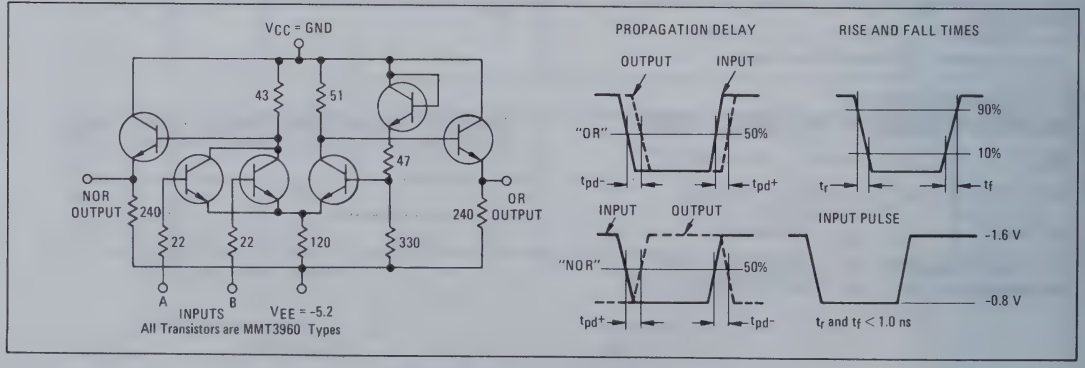
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	3.0	Vdc
Collector-Base Voltage	V_{CB}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	490	°C/W

FIGURE 1 – TWO INPUT OR/NOR ECL GATE



MMT3960 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}[1]	3.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	5.0	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 2.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	μAdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain[1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	100	–	200	–
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		80	–	–	
Collector-Emitter Saturation Voltage[1] (I_C = 10 mAdc, I_B = 1.0 mAdc	$V_{CE(sat)}$	–	–	0.2	Vdc
Base-Emitter Saturation Voltage[1] (I_C = 10 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	0.7	–	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)	f_T	–	2000	–	MHz
(I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		–	2250	–	
(I_C = 30 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		1600	2600	–	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	1.3	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	1.2	3.0	pF
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 2.0 Vdc, f = 100 MHz)	$r_b'C_c$	–	15	–	ps
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Delay Time	$t_{d(on)}$	–	0.95	–	ns
Rise Time	t_r	–	0.65	–	ns
Turn-Off Delay Time	$t_{d(off)}$	–	1.05	–	ns
Fall Time	t_f	–	0.75	–	ns

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT3960A (SILICON)

NPN SILICON ANNULAR TRANSISTOR

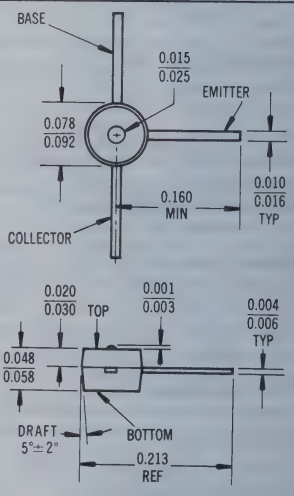
. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain—Bandwidth Product — f_T = 2250 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ob} = 1.3 pF (Typ) @ V_{CB} = 4.0 Vdc; C_{ib} = 1.2 pF (Typ) @ V_{BE} = 0.5 Vdc
- Excellent Current-Mode Performance — t_r = 0.75 ns (Typ)
- Low Collector-Base Time Constant — $r_b'C_c$ = 15 ps (Typ) @ I_C = 30 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON HIGH-SPEED SWITCHING TRANSISTOR





CASE 28(1)

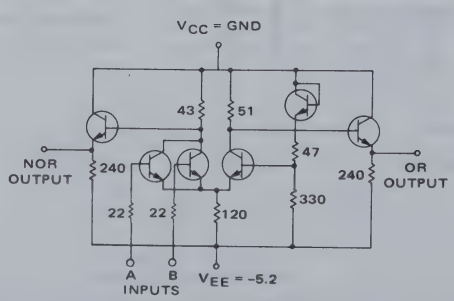
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

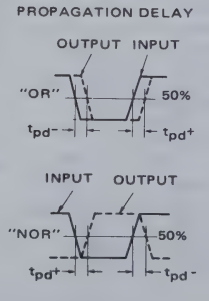
THERMAL CHARACTERISTICS

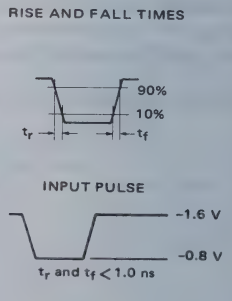
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — TWO INPUT OR/NOR ECL GATE



All Transistors are MMT3960A Types





ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	-	200	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.75	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		-	2000	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		-	2250	-	
(I_C = 30 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		1600	2500	-	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	1.3	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	1.2	3.0	pF
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 2.0 Vdc, f = 100 MHz)	$r_b'C_c$	-	15	-	ps
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (Figure 1)	$t_{on(delay)}$	-	1.0	-	ns
Rise Time (Figure 1)	t_r	-	0.75	-	ns
Turn-Off Delay Time (Figure 1)	$t_{off(delay)}$	-	1.1	-	ns
Fall Time (Figure 1)	t_f	-	0.85	-	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT8015 (SILICON)

NPN SILICON RF SMALL–SIGNAL TRANSISTOR

. . . designed for low-noise, high-gain, small-signal microwave amplifiers. Ideal for microstrip circuits where high density packaging is required.

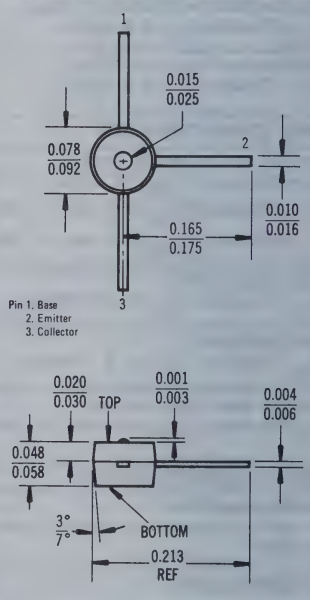
- Unneutralized Power Gain –
  G_{PE} = 12 dB (Typ) @ f = 1.0 GHz
- Low Noise Figure –
  NF = 3.5 dB (Typ) @ f = 1.0 GHz
- Characterized with Scattering Parameters

NPN SILICON MICRO–T RF SMALL–SIGNAL TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	°C



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.35	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.0	–	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 250 MHz)	f_T	1000	2000	–	MHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.50	1.0	pF
Collector-Base Time Constant (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	4.0	–	ps
Noise Figure (1) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	–	3.2	4.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (1) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 1.0 GHz)	G_{pe}	6.0	7.5	–	dB
Common-Emitter Amplifier Power Gain (2) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, f = 1.0 GHz)	G_{pe}	10	13	–	dB

(1) Biased For Minimum Noise
(2) Biased For Optimum Gain

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

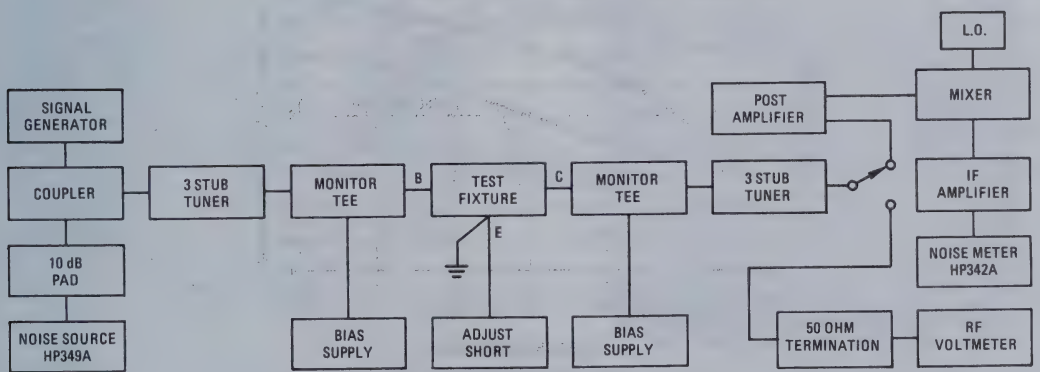


FIGURE 2 – COLLECTOR–BASE CAPACITANCE versus VOLTAGE

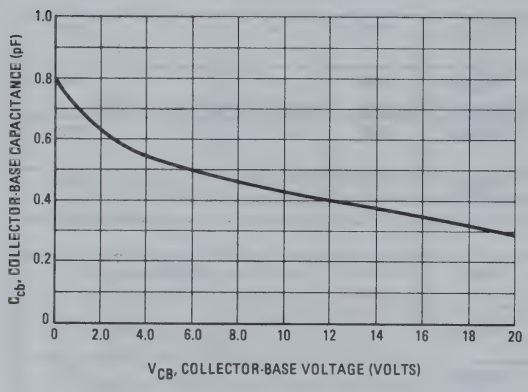


FIGURE 3 – CURRENT–GAIN – BANDWIDTH PRODUCT

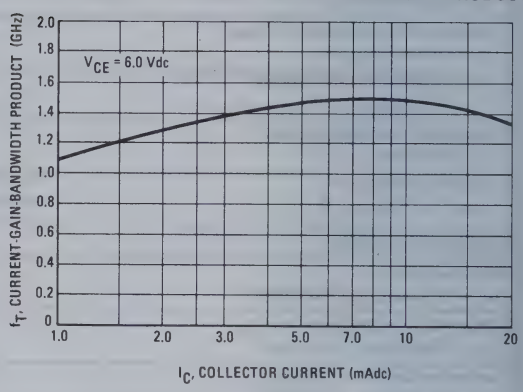


FIGURE 4 – NOISE FIGURE versus FREQUENCY

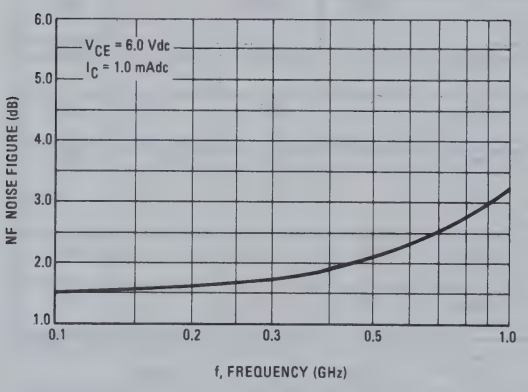


FIGURE 5 – UNNEUTRALIZED POWER GAIN versus FREQUENCY

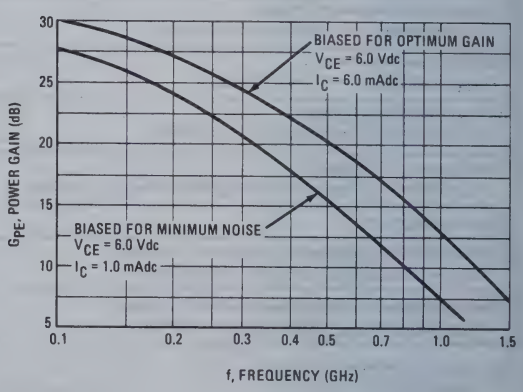
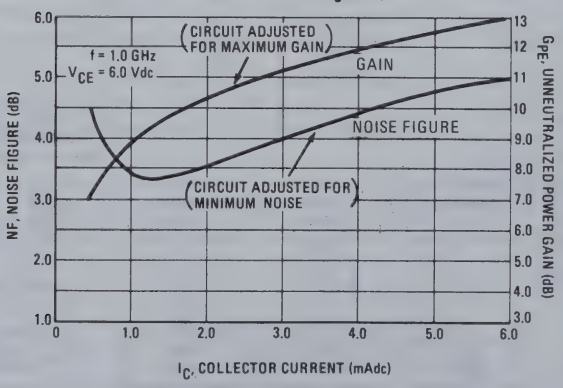


FIGURE 6 – NOISE FIGURE AND GAIN versus CURRENT
(See Test Circuit Figure 1)



S_{11}, S_{22}, INPUT AND OUTPUT REFLECTION COEFFICIENTS

V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc

FIGURE 7

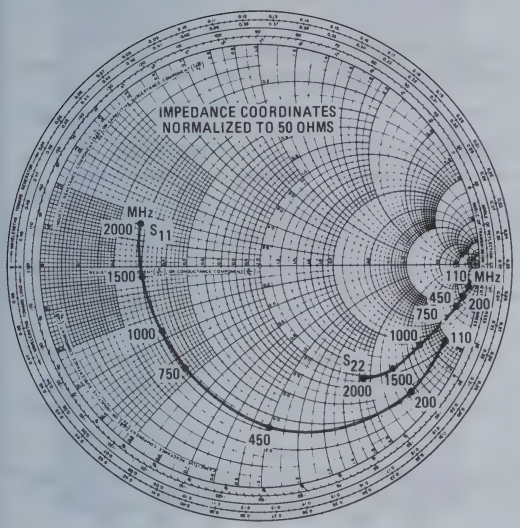
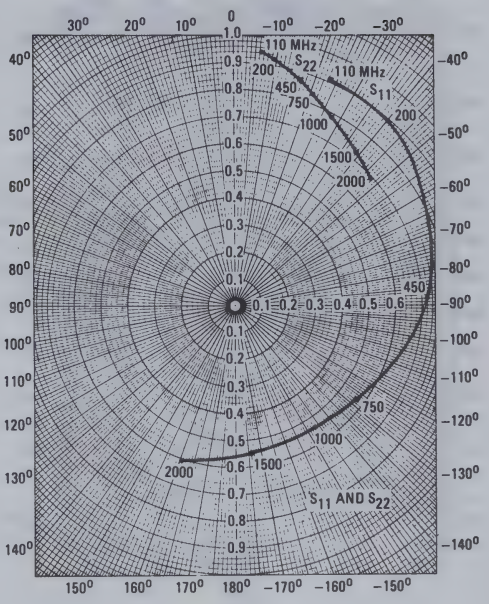


FIGURE 8



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc

FIGURE 9

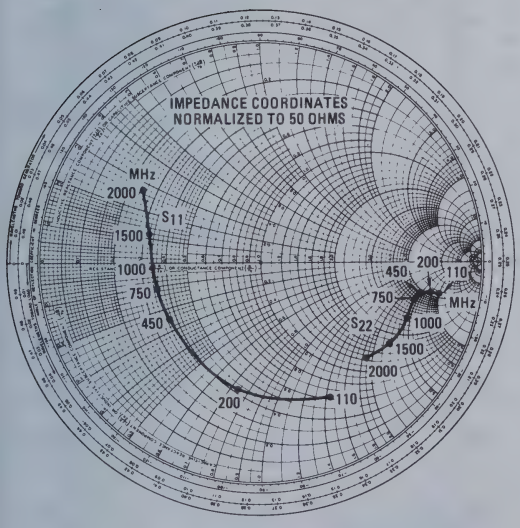
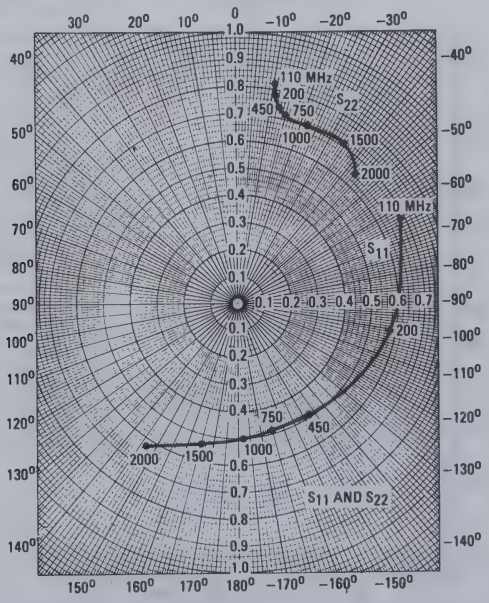


FIGURE 10



S_{12}, REVERSE TRANSMISSION COEFFICIENT

S_{21}, FORWARD TRANSMISSION COEFFICIENT

V_{CC} = 6.0 Vdc, I_C = 1.0 mAdc, $Z_G = Z_L$ = 50 Ohms

FIGURE 11

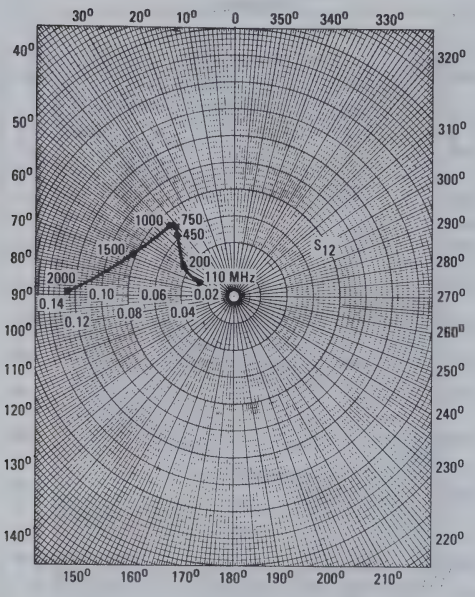
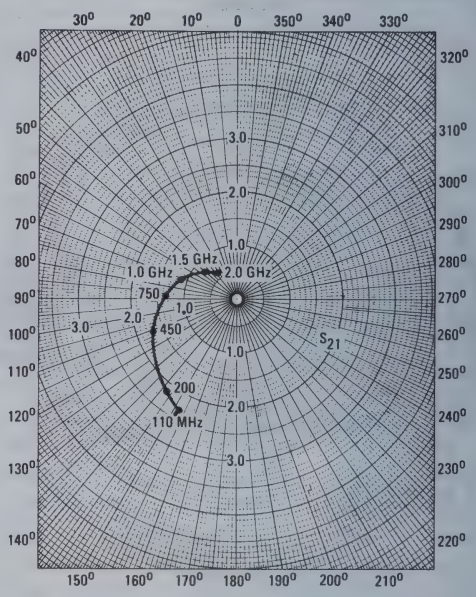


FIGURE 12



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, $Z_G = Z_L$ = 50 Ohms

FIGURE 13

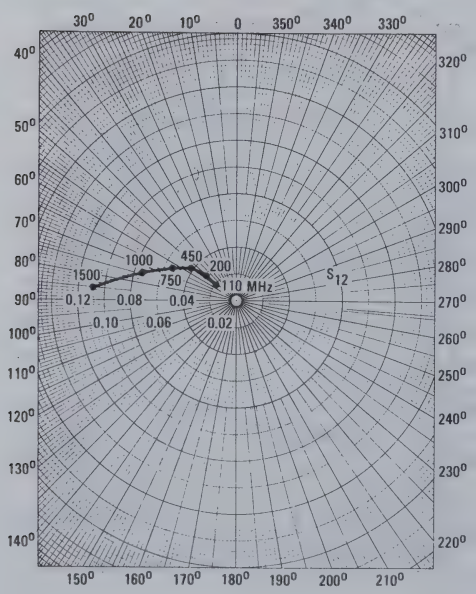
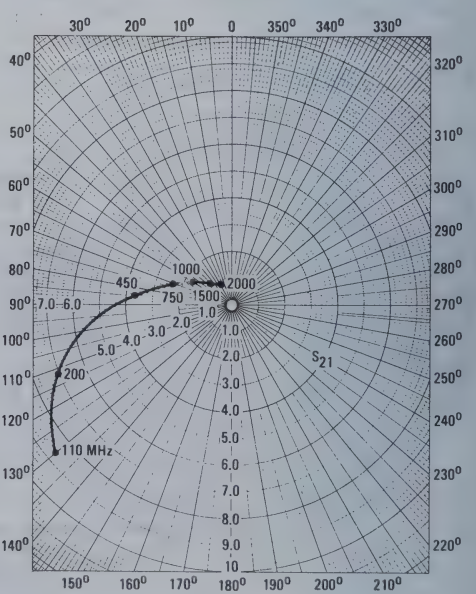


FIGURE 14



MOC2000

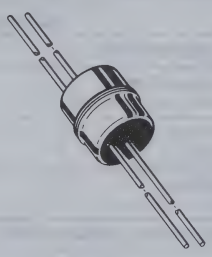
Advance Information

NPN PHOTOTRANSISTOR AND PN INFRARED EMITTING DIODE

. . . Gallium Arsenide LED optically coupled to a Silicon Photo Transistor designed for applications requiring electrical isolation, high-current transfer ratios, small package size and low cost; such as interfacing and coupling systems, phase and feedback controls, solid-state relays and general-purpose switching circuits.

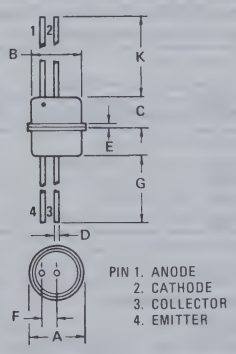
- High Voltage Electrical Isolation — 1500 V Min
- Hermetically Sealed Package
- Fast Switching — 2.8 μs (Typ)
- Excellent Coupling Characteristic
  I_{CL} = 0.5 mA (min) @ I_F = 15 mA
  I_{CL} = 1.6 mA (Min) @ I_F = 35 mA

HERMETIC OPTOELECTRONIC COUPLER PHOTOTRANSISTOR/IR LED COUPLED PAIR



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE MAXIMUM RATINGS			
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Forward Current-Peak (1.0 μs Pulse, 300 pps)	I_F	3.0	Amp
PHOTOTRANSISTOR MAXIMUM RATINGS			
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CBO}	70	Volts
TOTAL DEVICE MAXIMUM RATINGS			
Total Device Dissipation @ T_A = 25°C Derate above T_A = 25°C	P_D	150 1.5	mW mW/°C
Junction Temperature Range	T_J	−55 to +125	°C
Storage Temperature Range	T_{stg}	−55 to +150	°C
Lead Soldering Time T = 240°C, 1/16" from case		10	sec



PIN 1. ANODE
2. CATHODE
3. COLLECTOR
4. EMITTER

NOTE:
POLARITY DOT ON PACKAGE
DENOTES DIODE ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	4.95	0.185	0.195
B	4.06	4.32	0.160	0.170
C	2.41	2.67	0.095	0.105
D	0.38	0.51	0.015	0.020
E	0.15	0.25	0.006	0.010
F	1.27 BSC		0.050 BSC	
G	26.67	30.48	1.050	1.200
K	20.32	24.13	0.800	0.950

CASE 271-01

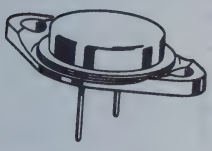
This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
LED CHARACTERISTICS					
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 M Ω	I_R	–	–	100	μA
Forward Voltage (I_F = 50 mA)	V_F	–	–	1.5	Volts
Input Capacitance (V_R = 0, f = 1.0 MHz)	C_j	–	150	–	pF
PHOTOTRANSISTOR CHARACTERISTICS					
Collector-Emitter Dark Current (V_{CE} = 30 V, I_F = 0, Base Open)	I_{CEO}	–	–	25	nA
Collector-Emitter Breakdown Voltage (I_C = 1.0 mA, Base Open)	BV_{CEO}	30	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA, Base Open)	BV_{ECO}	7.0	–	–	Volts
DC Current Gain (V_{CE} = 5.0 V, I_C = 100 μA)	h_{FE}	–	200	–	–
COUPLED CHARACTERISTICS					
Collector Light Current (V_{CE} = 50 V, I_F = 15 mA)	I_{CL_1}	0.5	–	–	mA
Collector Light Current (V_{CE} = 5.0 V, I_F = 35 mA)	I_{CL_2}	1.6	–	–	mA
Isolation Voltage (1) (60 Hz)	–	1500	–	–	Volts
Isolation Resistance (1) (V = 500 V)	–	–	10^{13}	–	Ohms
Collector-Emitter Saturation Voltage (I_C = 125 μA, I_F = 15 mA)	$V_{CE(sat)}$	–	–	0.3	Volts

(1) For this test, LED pins 1 and 2 are common, and PHOTOTRANSISTOR pins 3 and 4 are common.

MP110 (GERMANIUM)



PNP germanium power transistor designed for high-gain power amplification in the audio range.

CASE 11
(TO-3)

Pin 1. Base
2. Emitter

Collector connected to case

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	MP110	Unit
Collector-Emitter Voltage	V_{CEX}	65	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector Current-Continuous Peak	I_C	7.0 15	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, $V_{BE(off)}$ = 2 Vdc	BV_{CEX}	65	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 Adc, R_{BE} = 68 ohms)	BV_{CER}	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.2 Adc, V_{BE} = 0)	BV_{CES}	50	—	—	Vdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_J = 75°C)	I_{CBO}	 — — —	 — — —	 0.2 2.0 15	mAdc
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	I_{EBO}	—	—	8.0	mAdc
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	V_{FL}	—	—	0.8	Vdc
ON CHARACTERISTICS					
DC Current Gain (See Note) (I_C = 50 mAdc, V_{CE} = 2 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	 60 74	 — —	 — 250	—
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	f_T	—	320	—	kHz

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

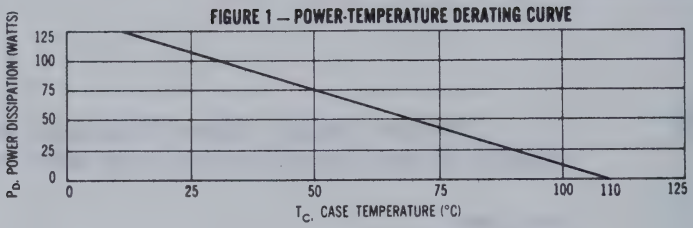


FIGURE 2 — DC CURRENT GAIN

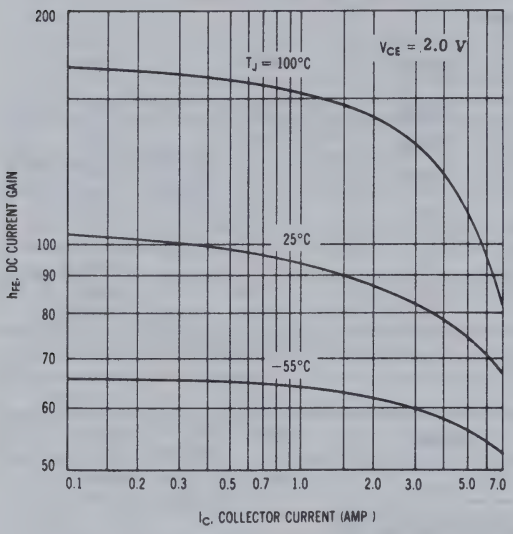


FIGURE 3 — TRANSCONDUCTANCE

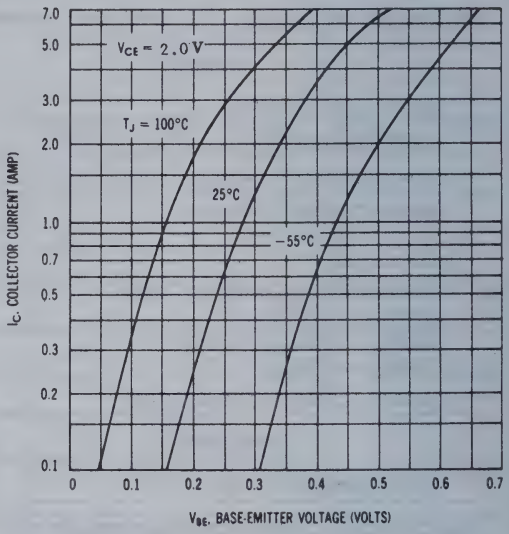


FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA

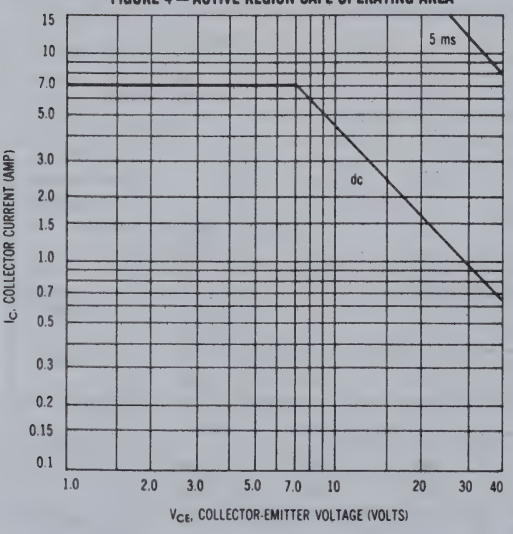
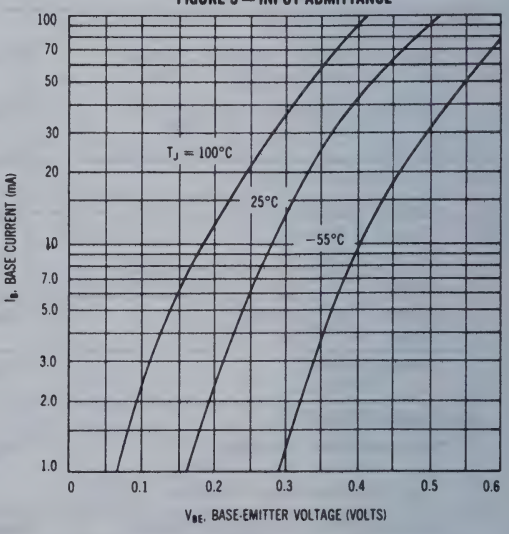


FIGURE 5 — INPUT ADMITTANCE



NOTE: Transistors are color coded to identify gain ranges as shown. No guarantee is made of gain distribution.
$I_C = 1$ Adc, $V_{CE} = 2$ Vdc

COLOR CODE	h_{FE}	
	Min.	Max.
red	74	111
orange	100	133
yellow	119	164
green	145	200
blue	179	250

MP110B (GERMANIUM)

PNP GERMANIUM POWER SWITCHING TRANSISTOR

. . . designed for high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc @ I_C = 5.0 Adc

25 AMPERE

PNP ADE GERMANIUM POWER TRANSISTOR

90 VOLTS
106 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W



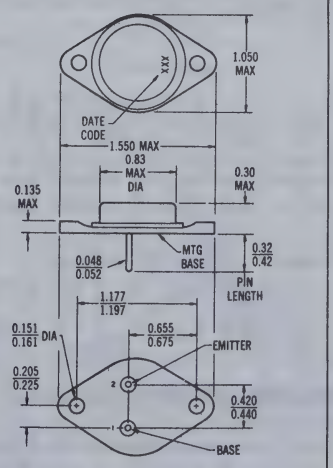
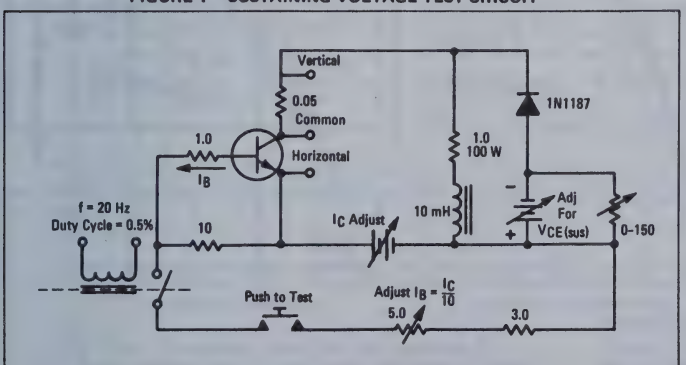


FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 Adc) (See Figure 1)	$V_{CE(sus)}$	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)	BV_{EBO}	2.0	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, R_{EB} = 100 Ohms)	I_{CER}	-	10	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	I_{CEX}	-	20	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)* Red Green Blue (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	65 100 150 55	120 200 300 -	-
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	- -	0.45 0.60	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)	f_T	500	-	kHz

*For desired h_{FE} range, specify color code.

MP500 thru MP502 (GERMANIUM)
MP504 thru MP506

CASE 7



Collector connected to case

PNP germanium power transistors for high-gain, high-power amplifier and switching applications in high reliability industrial equipment.

Pin 1. Base
2. Emitter

MAXIMUM RATINGS

Rating	Symbol	MP500 MP504	MP501 MP505	MP502 MP506	Unit
Collector-Base Voltage	V_{CB}	45	60	75	Volts
Collector-Emitter Voltage	V_{CES}	45	60	75	Volts
Collector-Emitter Voltage	V_{CEO}	30	45	60	Volts
Emitter-Base Voltage	V_{EB}	25	30	40	Volts
Collector Current	I_C	60	60	60	Amp
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	Watts
Junction Temperature Range	T_J	← -65 to+ 110 →			^oC

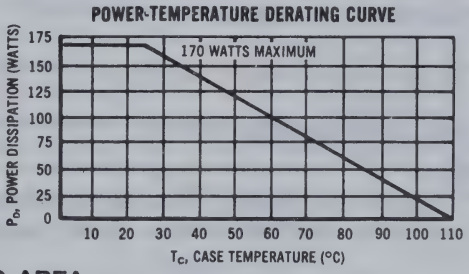
POWER DERATING

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

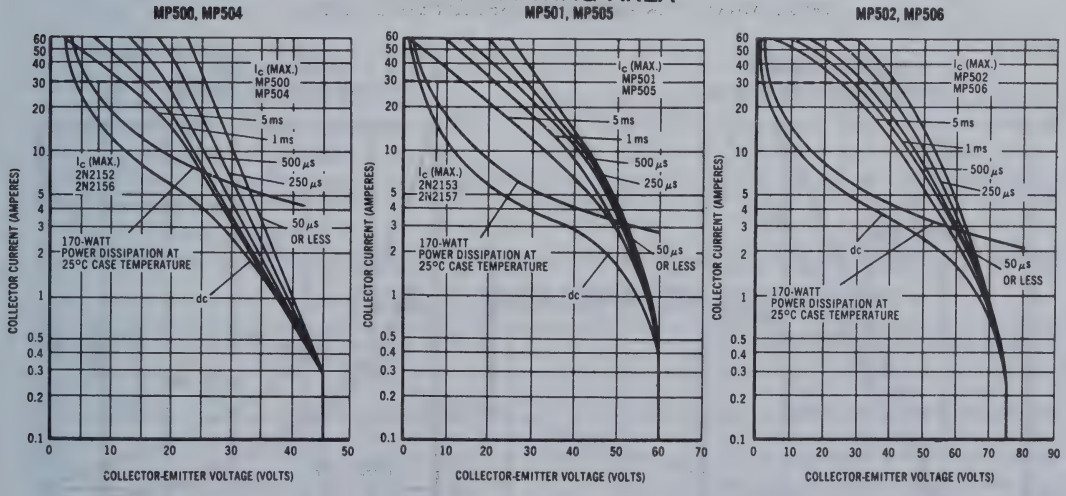
This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

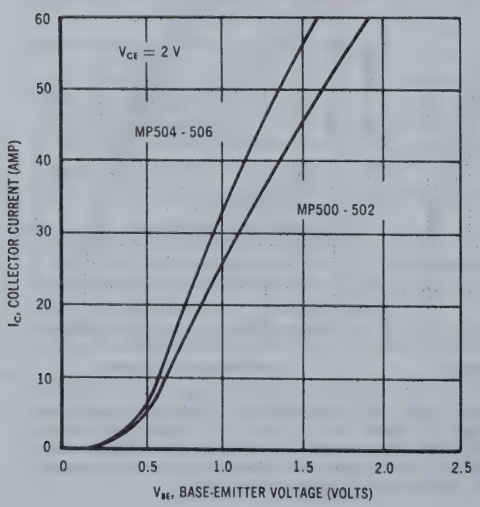
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}				mAdc
(V_{CB} = -45 V, I_E = 0)	MP500 MP504		—	0.9	4.0	
(V_{CB} = -60 V, I_E = 0)	MP501 MP505		—	0.9	4.0	
(V_{CB} = -75 V, I_E = 0)	MP502 MP506		—	0.9	4.0	
Collector-Base Cutoff Current (V_{CB} = V_{CBmax}, I_E = 0, T_C = +71°C)		I_{CBO}	—	4.0	15	mAdc
Collector-Base Cutoff Current (V_{CB} = -2 V, I_E = 0)		I_{CBO}	—	80	200	μAdc
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = -25 V, I_C = 0)	MP500 MP504		—	0.2	4.0	
(V_{EB} = -30 V, I_C = 0)	MP501 MP505		—	0.2	4.0	
(V_{EB} = -40 V, I_C = 0)	MP502 MP506		—	0.2	4.0	
Emitter-Base Cutoff Current (V_{EB} = $V_{EB\,max}$, I_C = 0, T_C = +71°C)		I_{EBO}	—	2.7	15	mAdc
Collector-Emitter Breakdown Voltage (1)		BV_{CES}				Vdc
(I_C = 300 mA, V_{EB} = 0)	MP500 MP504		-45	—	—	
	MP501 MP505		-60	—	—	
	MP502 MP506		-75	—	—	
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 1.0 A, I_B = 0)	MP500 MP504		-30	—	—	
	MP501 MP505		-45	—	—	
	MP502 MP506		-60	—	—	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 45 V, I_E = 0)	MP500 MP504		—	—	1.0	
(V_{CB} = 60 V, I_E = 0)	MP501 MP505		—	—	1.0	
(V_{CB} = 75 V, I_E = 0)	MP502 MP506		—	—	1.0	
DC Current Transfer Ratio		h_{FE1}				—
(I_C = 15 A, V_{CE} = 2 V)	MP500 through MP502		30	47	60	
	MP504 through MP506		50	63	100	
(I_C = 50 A, V_{CE} = 2 V)	All Types	h_{FE}	12	20	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.11	0.2	
(I_C = 50 A, I_B = 5 A)			—	0.2	0.45	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.7	1.5	
(I_C = 50 A, I_B = 5 A)			—	2.0	2.5	
Common Emitter Cutoff Frequency (I_C = 15 A, V_{CE} = 2 V)		f_{be}	2.0	3.6	—	kHz

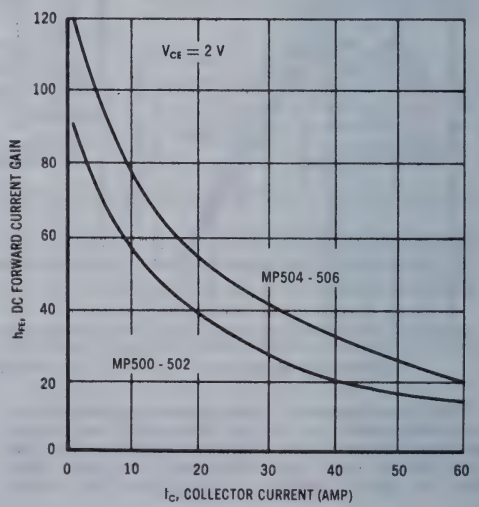
(1) To avoid excessive heating of collector junction, perform this test with a sweep method.

INPUT AND TRANSFER CHARACTERISTICS

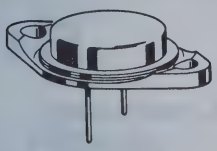
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



MP525 (GERMANIUM)



CASE 3
(TO-3 modified)
Collector connected to case

Germanium PNP power transistor designed for audio amplifier applications requiring gains of 30 — 150 at I_C = 3 amp.

Pin 1. Base
2. Emitter

MAXIMUM RATINGS

Rating	Symbol	MP525	Unit
Collector-Emitter Voltage	V_{CEX}	60	Vdc
Collector Current (Continuous)	I_C	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Junction Temperature Range	T_J	-65 to +110	°C
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 300 mA, R_{BE} = 10 ohms)	BV_{CER}	35	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 0)	I_{CES}	-	15	mA
Collector-Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	I_{CEX}	-	15	mA
Collector-Base Cutoff Current (V_{CB} =2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μA
DC Current Gain (I_C = 3.0Adc, V_{CE} = 2.0 Vdc)	h_{FE}	30	150	-

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

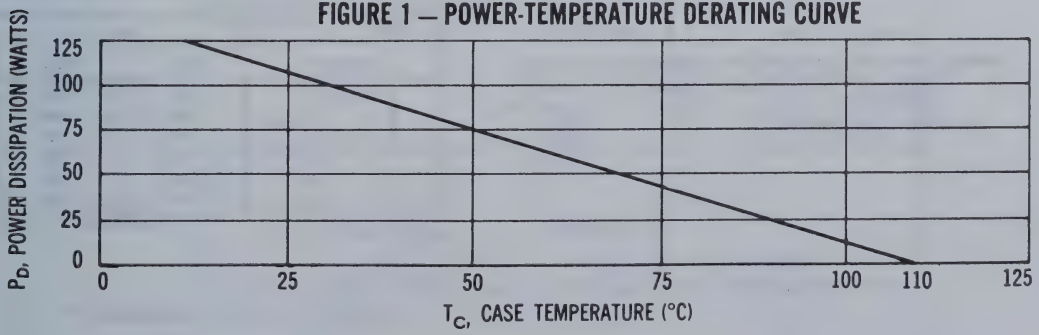


FIGURE 2 — DC CURRENT GAIN

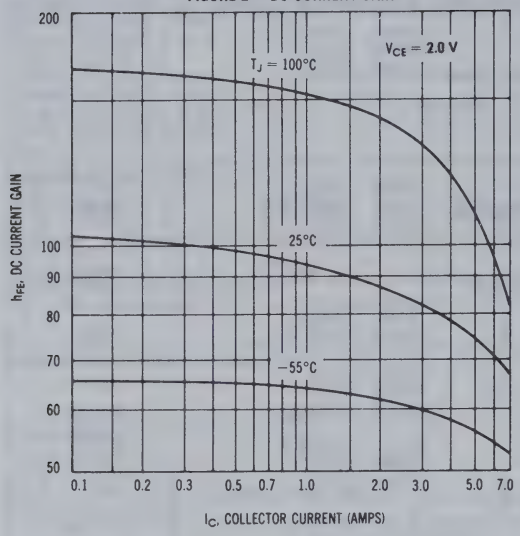


FIGURE 3 — TRANSCONDUCTANCE

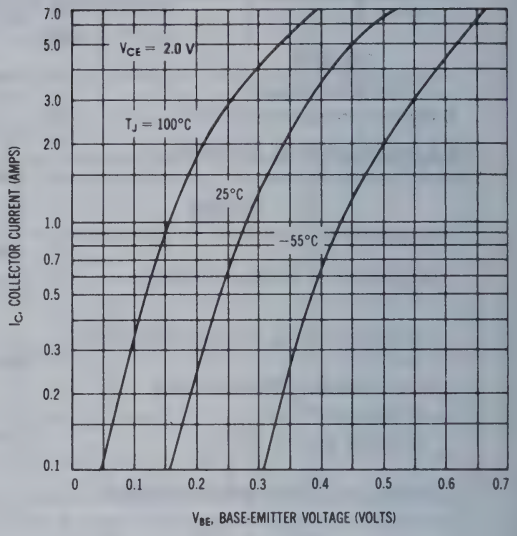


FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA

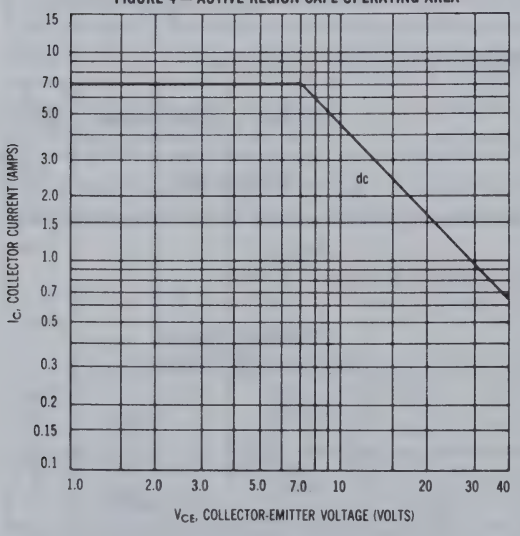
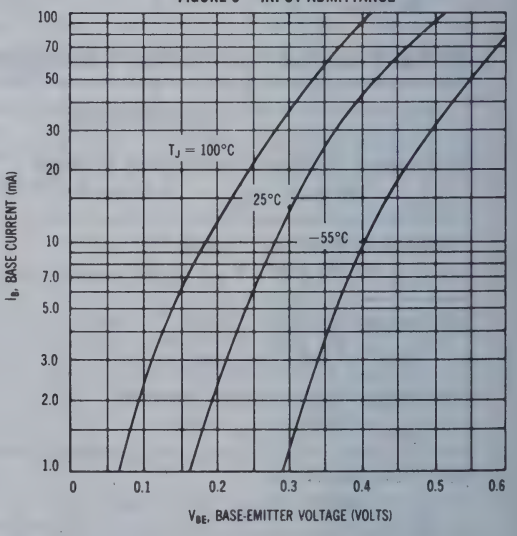


FIGURE 5 — INPUT ADMITTANCE



NOTE: Transistors are numerically coded to identify gain ranges as shown. No guarantee is made of gain distribution.
$I_C = 3$ Adc, $V_{CE} = 2.0$ V dc

Bracket	h_{FE}	
	Min.	Max.
MP525-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

MP600 (GERMANIUM) thru MP603



Collector Connected to Case
CASE 11A
(TO-3 modified)

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.2 Vdc (Max) @ I_C = 25 Adc

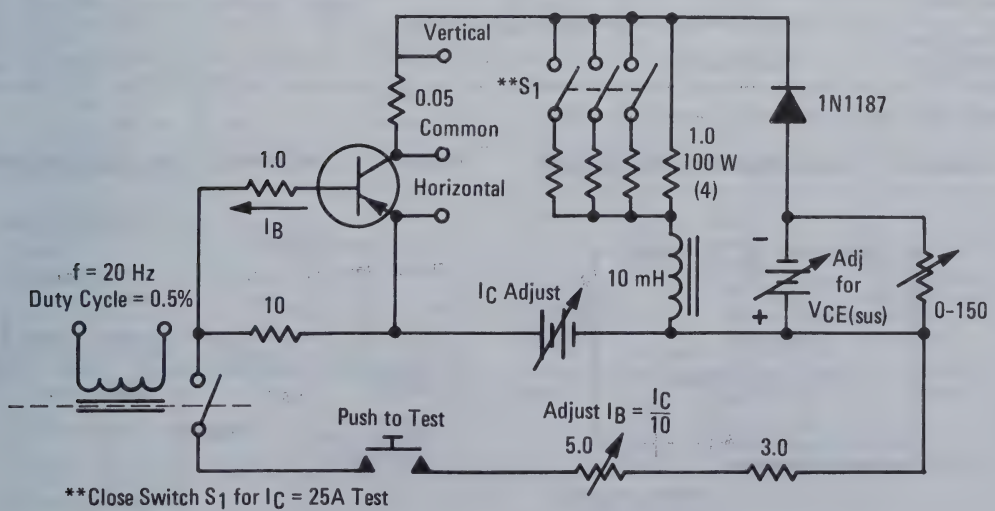
MAXIMUM RATINGS

Rating	Symbol	MP600	MP601	MP602	MP603	Unit
Collector-Emitter Voltage	V_{CEO}	50	60	70	80	Vdc
Collector-Base Voltage	V_{CB}	75	75	90	90	Vdc
Emitter-Base Voltage	V_{EB}	1.5				Vdc
Collector Current - Continuous	I_C	25				Adc
Base Current - Continuous	I_B	5.0				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS:					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	MP600	BV_{CEO}	50	-	Vdc
	MP601		60	-	
	MP602		70	-	
	MP603		80	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc)	MP600	$V_{CE(sus)}$	50	-	Vdc
	MP601		60	-	
	MP602		70	-	
	MP603		80	-	
(I_C = 25 Adc)	MP600		30	-	
	MP601		40	-	
	MP602		40	-	
	MP603		50	-	
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)		BV_{EBO}	1.5	-	Vdc
Floating Potential (V_{CB} = 60 Vdc, I_E = 0)		V_{EBF}	-	0.4	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP600, MP601	I_{CEX}	-	10	mAdc
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP602, MP603		-	10	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	200	μAdc
Emitter Cutoff Current (V_{EB} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	50	-	-
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)		$V_{CE(sat)}$	-	0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)		$V_{BE(sat)}$	-	1.2	Vdc
Emitter-Base On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		$V_{EB(on)}$	-	0.6	Vdc
Pulse Energy Test (See Figure 2) (1) (I_C = 3.3 Adc, V_{CE} = 30 Vdc)		PET	1.0	-	Joule
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 22 Vdc, I_C = 15 Adc, I_{B1} = I_{B2} = 1.5 Adc) See Figure 3	t_r	-	10	μs
Storage Time		t_s	-	6.0	μs
Fall Time		t_f	-	13	μs

(1) Pulse Test: Pulse Width = 10 ms, Duty Cycle = 2.5%.

FIGURE 2 – PULSE ENERGY TEST CIRCUIT

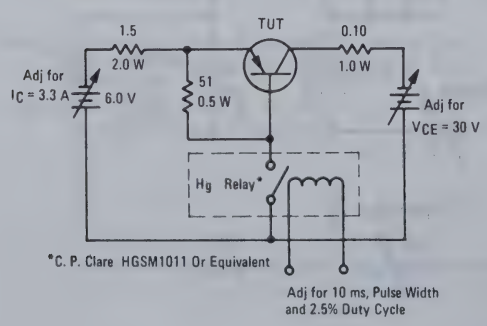
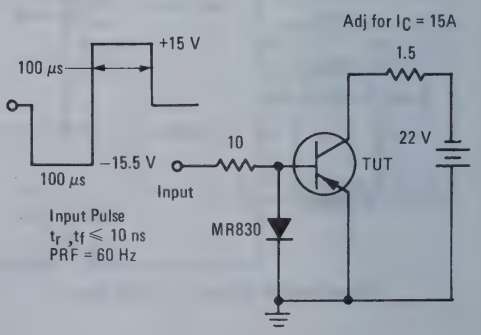
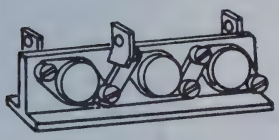


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MP800 (GERMANIUM)
MP801



CASE 118

PNP germanium power transistor designed for ultra-high current applications requiring high gain and extremely low saturation voltage. Collector electrically isolated from heat sink.

MAXIMUM RATINGS

Rating	Symbol	MP800	MP801	Unit
Collector-Emitter Voltage	V_{CEO}	60	45	Vdc
Collector-Emitter Voltage	V_{CES}	75	60	Vdc
Emitter-Base Voltage	V_{EB}	20		Vdc
Collector Current*	I_C*	150		Amp
Total Device Dissipation @ T_C = 25°C	P_D	250		Watts
Operating Junction Temperature Range	T_J	-65 to +110		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.33	°C/W

ELECTRICAL CHARACTERISTICS

** For Epoxy Encapsulated unit, add "A" to device type, i.e. MP800A

(T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 Adc, I_B = 0)	MP800	BV_{CEO}	60	-	Vdc
	MP801		45	-	
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	MP800	I_{CBO}	-	12	mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MP801		-	12	
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	15	-	-
Collector-Emitter Saturation Voltage (I_C = 150 Adc, I_B = 15 Adc)		$V_{CE(sat)}$	-	0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 150 Adc, I_B = 15 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
Safe Operating Area	(Figure 1)	SOA			Volts
100% Test - Clamped V_{CE}	MP800		-	45	
	MP801		-	40	

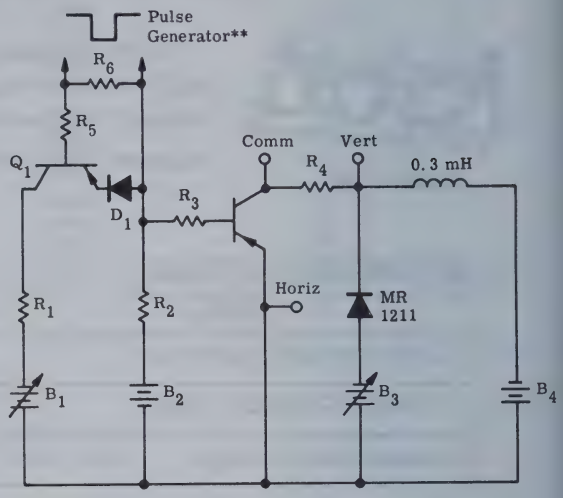
* For currents above 150 Amp, contact your local representative.

FIGURE 1 — SAFE OPERATING AREA TEST CURRENT

R_1 = 1.0Ω, 200 W
R_2 = 10Ω, 2.0 W
R_3 = 0.1Ω, 1%, 20 W
R_4 = 0.001Ω
R_5 = 10Ω, 2.0 W
R_6 = 50Ω, 1.0 W
Q_1 = 2N2832
D_1 = 1N1183

B_1 = Adj for $I_{B(on)}$ = 15 A
B_2 = 6.0 V
B_3 = Adj for clamped V_{CE}
B_4 = 20 V

** Adj P. W. to obtain I_C = 150 A



MP1612, A, B (GERMANIUM)

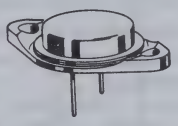
PNP GERMANIUM POWER TRANSISTORS

. . . high-speed, high-frequency transistors for television horizontal deflection requiring:

- Fast Switching — Fall Time Typically 0.7 μs in Horizontal Output Stages of CRT Deflection Circuits
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 10 Adc
- Large, Specified Safe Operating Area

20 AMPERE
POWER TRANSISTORS
PNP GERMANIUM

100-140-160 VOLTS
85 WATTS

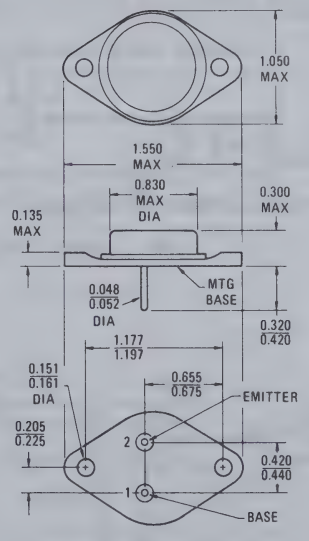


MAXIMUM RATINGS

Rating	Symbol	MP1612	MP1612A	MP1612B	Unit
Collector-Emitter Voltage	V_{CES}	100	140	160	Vdc
Collector-Base Voltage	V_{CB}	100	140	160	Vdc
Emitter-Base Voltage	V_{EB}	2.5			Vdc
Collector Current — Continuous	I_C	20			Adc
Base Current — Continuous	I_B	5.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0			Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +110			°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)		BV_{EBO}	2.5	—	Vdc
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 100 Vdc, V_{BE} = 0)	MP1612		—	20	
(V_{CE} = 140 Vdc, V_{BE} = 0)	MP1612A		—	20	
(V_{CE} = 160 Vdc, V_{BE} = 0)	MP1612B		—	20	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 50 Vdc, V_{BE} = 0.2 Vdc, T_C = +85°C)	MP1612		—	40	
(V_{CE} = 75 Vdc, V_{BE} = 0.2 Vdc, T_C = +85°C)	MP1612A		—	40	
(V_{CE} = 100 Vdc, V_{BE} = 0.2 Vdc, T_C = +85°C)	MP1612B		—	40	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 80 Vdc, I_E = 0)	MP1612		—	10	
(V_{CB} = 120 Vdc, I_E = 0)	MP1612A		—	10	
(V_{CB} = 140 Vdc, I_E = 0)	MP1612B		—	10	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			40	—	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)			25	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			—	0.3	
(I_C = 20 Adc, I_B = 2.0 Adc)			—	0.5	
SWITCHING CHARACTERISTICS					
Fall Time (Figure 5)		t_f			μs
(I_C = 5.0 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.25	
(I_C = 10 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.5	



To convert inches to millimeters multiply by 25.4

Collector connected to case

CASE 11A
(TO-3 Except Pin Diameter)

SAFE OPERATING AREAS

FIGURE 1 – MP1612

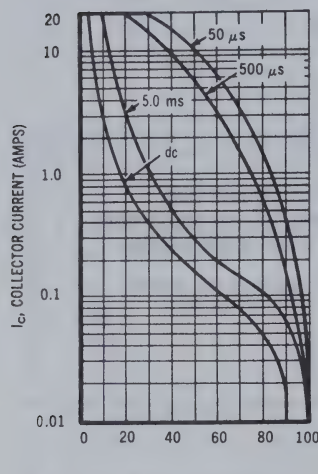


FIGURE 2 – MP1612A

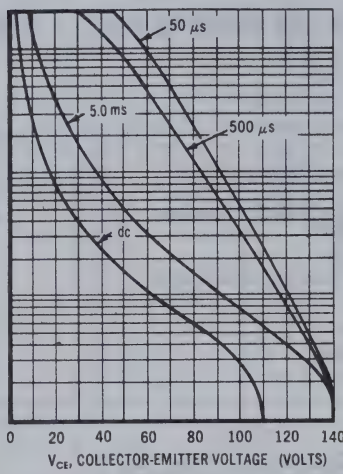
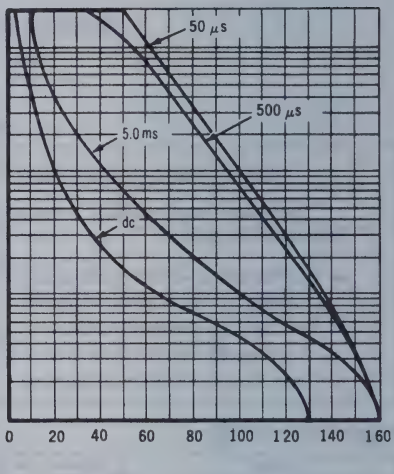


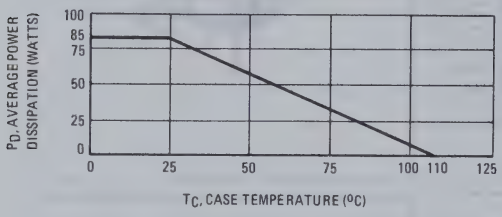
FIGURE 3 – MP1612B



V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)

The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

FIGURE 4 – POWER-TEMPERATURE DERATING CURVE



THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 1, 2, 3.

FIGURE 5 – FALL TIME TEST CIRCUIT

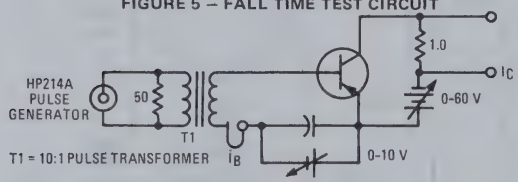


FIGURE 6 – BASE TURN-OFF CURRENT versus FALL TIME

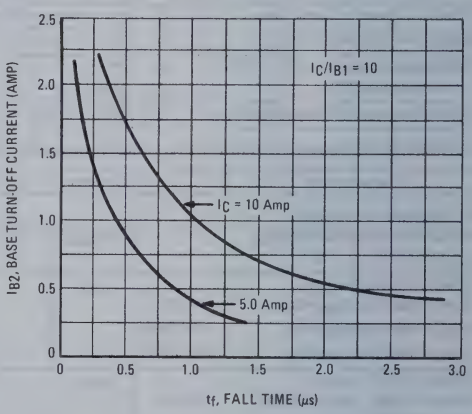
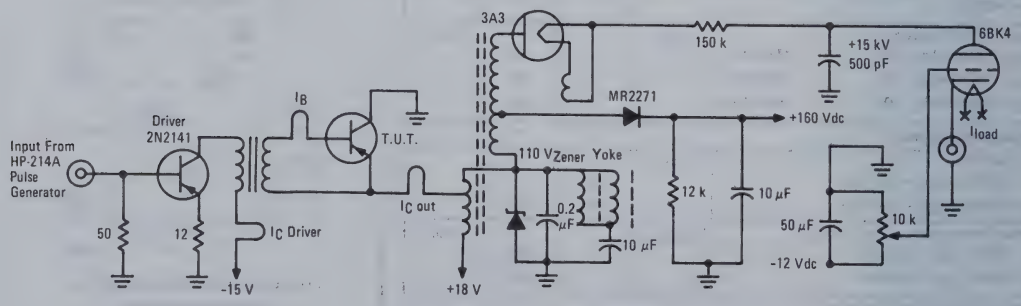
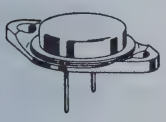


FIGURE 7 – LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MP1613 (GERMANIUM)



CASE 11
(TO-3)
Collector connected to case

Medium-current germanium PNP power transistor, designed for use in 12 Volt vertical deflection circuits in television receivers; features: high breakdown voltage, low leakage current, and low saturation voltage.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	75	Vdc
Collector-Emitter Voltage	V_{CES}	90	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	50	Vdc
Collector Current — Continuous	I_C	7.0	Adc
— Peak		15	Adc
Base Current — Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D	85	Watts
Derate above 25°C		1.0	W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

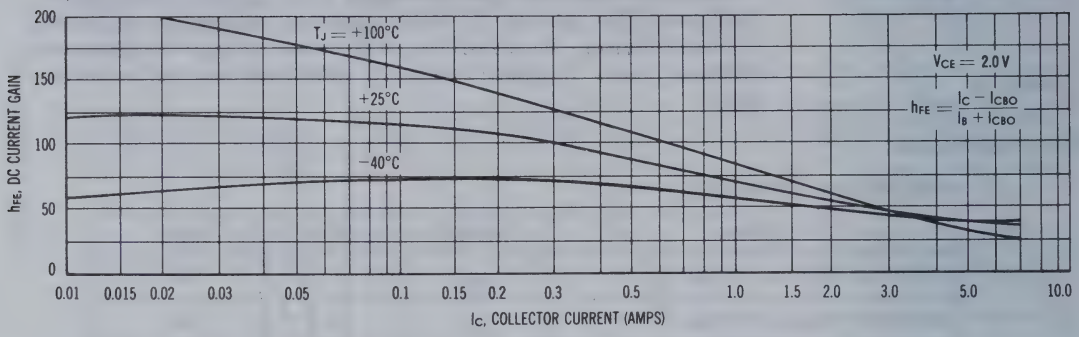
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

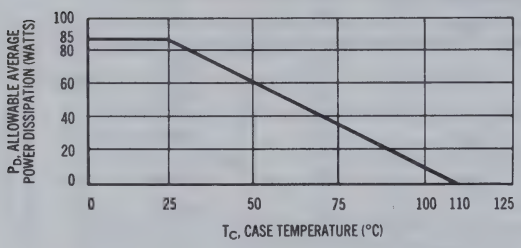
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 300 mAdc, I_B = 0)	BV_{CEO}	75	-	-	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 250 mAdc, V_{BE} = 0)	BV_{CES}	90	-	-	Vdc
Collector Cutoff Current (V_{CE} = 37.5 Vdc, I_B = 0)	I_{CEO}	-	-	30	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, V_{BE} = 1.0 Vdc, T_C = +100°C)	I_{CEX}	-	-	10	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	-	0.06	mAdc
(V_{CB} = V_{CB} max, I_E = 0)		-	-	5.0	
Emitter Cutoff Current (V_{BE} = 12 Vdc, I_C = 0)	I_{EBO}	-	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	-	120	200	-
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		40	70	-	
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	$V_{CE(sat)}$	-	-	0.25	Vdc

(1) Sweep Test: 1/2 sine wave, 60 Hz.

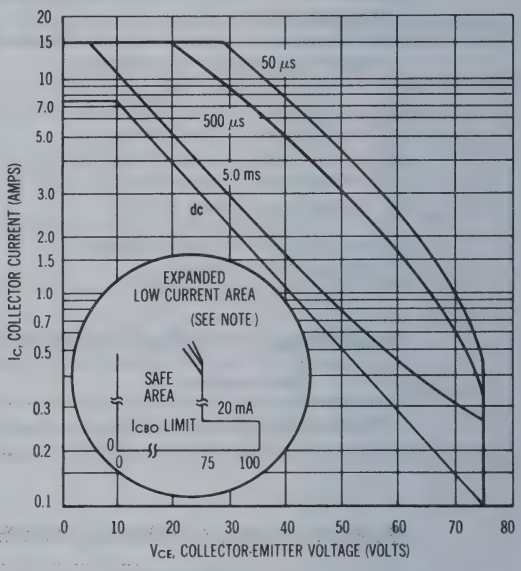
DC CURRENT GAIN versus COLLECTOR CURRENT



POWER-TEMPERATURE DERATING CURVE

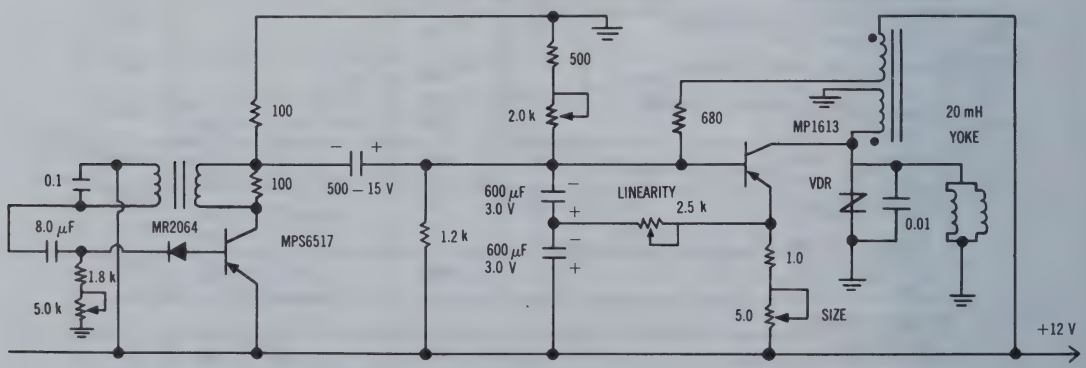


SAFE OPERATING AREAS



NOTE: — The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

12 VOLT VERTICAL DEFLECTION CIRCUIT



MP2000A (GERMANIUM)
MP2100A
MP2200A
MP2300A
MP2400A

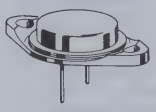
PNP GERMANIUM POWER TRANSISTORS

. . . designed for high-voltage switching, and power converter applications.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc
- Fast Switching Times –
  t_{on} = 11 μs (Typ) @ I_C = 10 Adc
  t_{off} = 21 μs (Typ) @ I_C = 10 Adc
- Guaranteed Excellent Safe Operating Area

25 AMPERES ADE POWER TRANSISTORS

30-120 VOLTS
106 WATTS



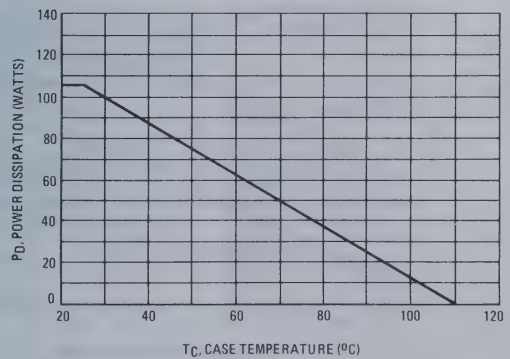
MAXIMUM RATINGS

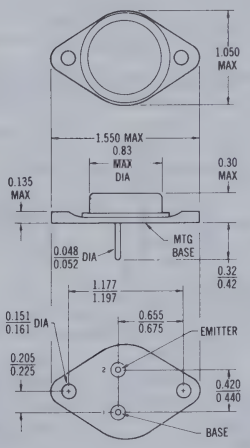
Rating	Symbol	MP2000A	MP2100A	MP2200A	MP2300A	MP2400A	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	2.0					Vdc
Collector Current-Continuous	I_C	25					Adc
Base Current – Continuous	I_B	5.0					Adc
Total Device Dissipation @ T_C = 25°C	P_D	106					Watts
Derate above 25°C		1.25					W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +110					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING





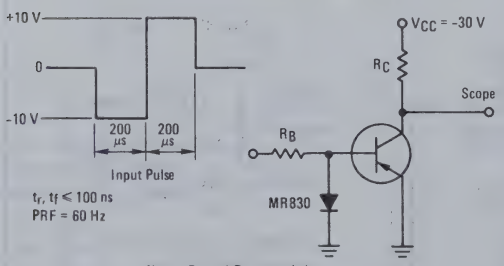
Collector Connected To Case
CASE 11A (1)
TO-3
Except Pin Diameter

(1) For devices with Lugs (TO-41) contact your local Motorola sales office.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 0.1 Adc, I_B = 0)	MP2000A		30	–	–	
	MP2100A		60	–	–	
	MP2200A		80	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
Collector-Emitter Sustinaing Voltage (Figure 7)		$V_{CE(sus)}$				Vdc
(I_C = 8.0 Adc)	MP2000A		60	–	–	
	MP2100A		80	–	–	
	MP2200A		90	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
(I_C = 25 Adc)	MP2000A		60	–	–	
	MP2100A		70	–	–	
	MP2200A		75	–	–	
	MP2300A		80	–	–	
	MP2400A		90	–	–	
Emitter-Base Breakdown Voltage (I_E = 0.5 Adc, I_C = 0)		BV_{EBO}	2.0	–	–	Vdc
Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2000A		–	–	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2100A		–	–	10	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2200A		–	–	10	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2300A		–	–	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2400A		–	–	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2000A		–	–	25	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2100A		–	–	25	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2200A		–	–	25	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2300A		–	–	25	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2400A		–	–	25	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	–	200	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{CE(sat)}$	–	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	–	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	–	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	–	430	–	kHz
Turn-On Time (Figure 2) (I_C = 10 Adc, I_{B1} = 1.0 Adc)		t_{on}	–	11	–	μs
Turn-Off Time (Figure 2) (I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)		t_{off}	–	21	–	μs

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



Note: R_B and R_C are varied to obtain desired test conditions.

FIGURE 3 – SWITCHING TIMES

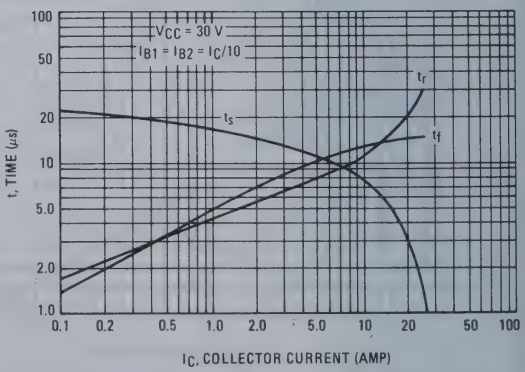


FIGURE 4 – THERMAL RESPONSE

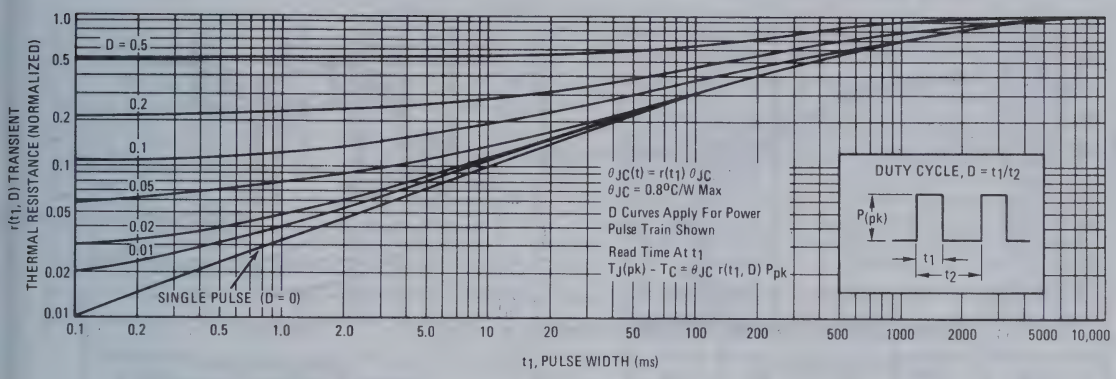


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

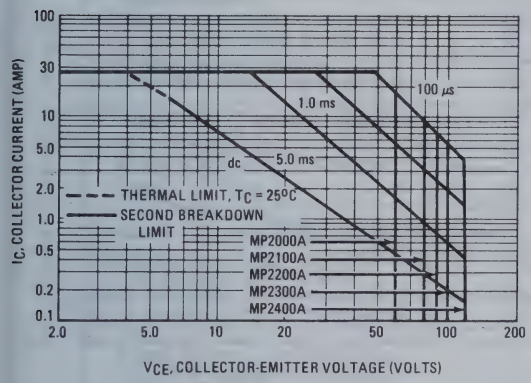
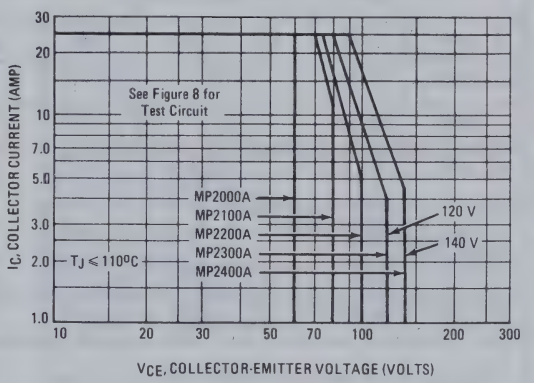


FIGURE 6 – CLAMPED INDUCTIVE SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 110^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 110^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

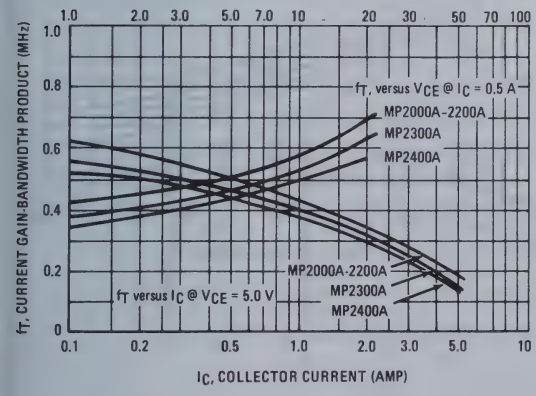


FIGURE 8 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT

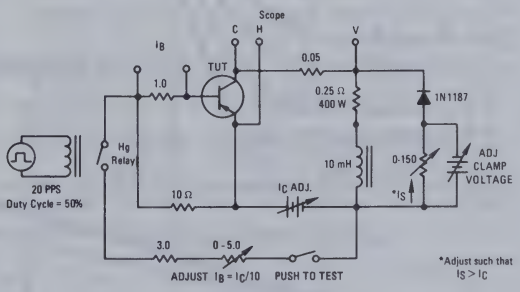


FIGURE 9 – DC CURRENT GAIN

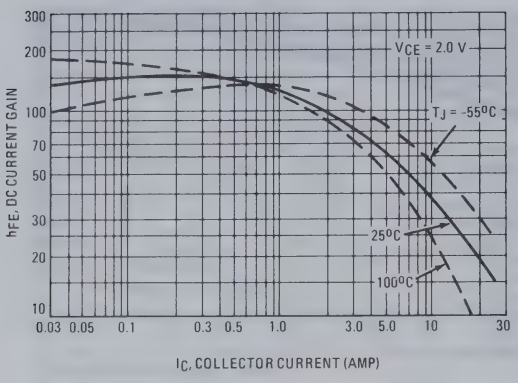


FIGURE 10 – COLLECTOR SATURATION REGION

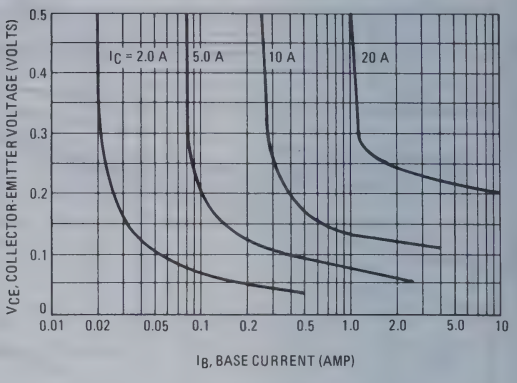


FIGURE 11 – "ON" VOLTAGES

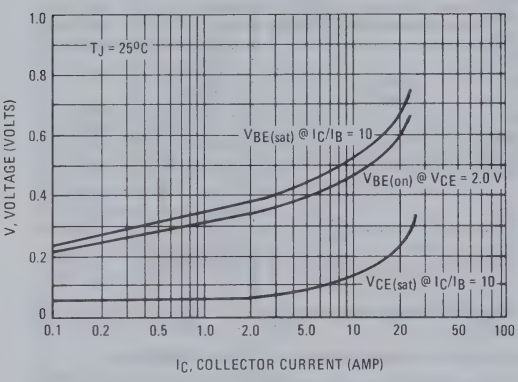


FIGURE 12 – TEMPERATURE COEFFICIENTS

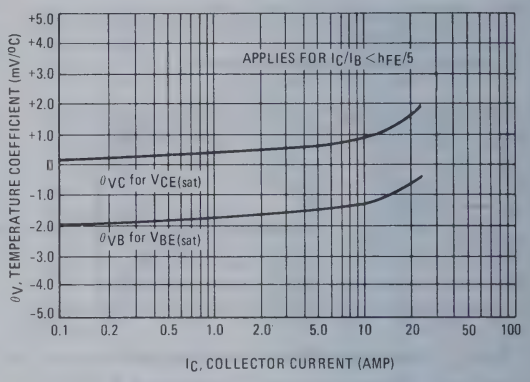


FIGURE 13 – COLLECTOR CUTOFF REGION

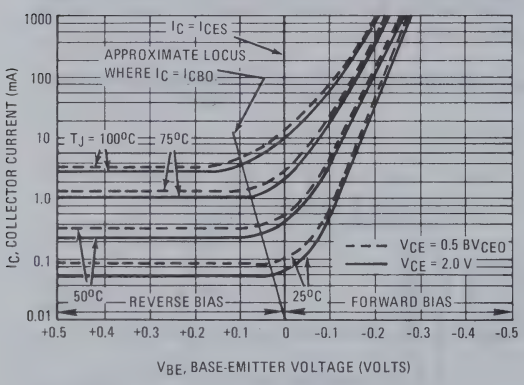
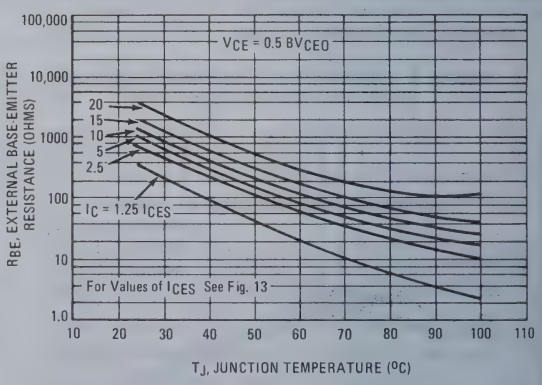
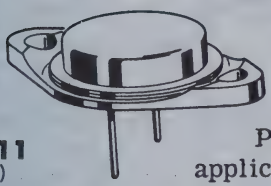


FIGURE 14 – EFFECTS OF BASE EMITTER RESISTANCE



MP2060 thru MP2063 (GERMANIUM)

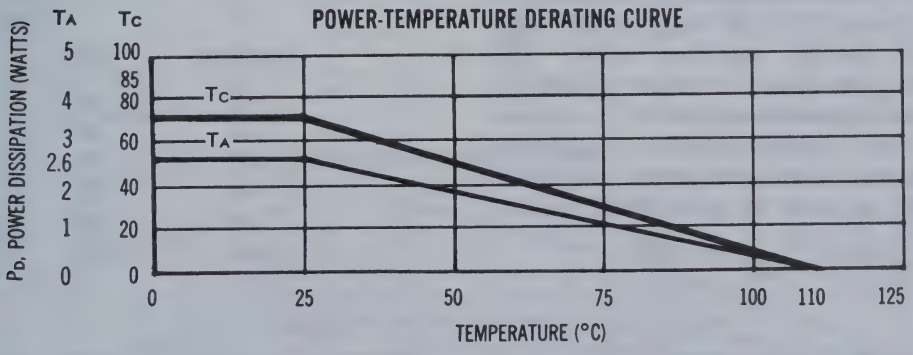


CASE 11
(TO-3)
Collector connected to case

PNP germanium power transistors for audio amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	MP2060	MP2061	MP2062	MP2063	Unit
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	75	90	Vdc
Emitter-Base Voltage	V_{EB}	← 20 →				Vdc
Collector Current (Continuous)	I_C	← 7.0 →				Adc
Peak Collector Current (PW ≦ 5 ms)	I_C	← 15 →				Adc
Base Current (Continuous)	I_B	← 2.0 →				Adc
Storage Temperature	T_{stg}	← -65 to +110 →				°C
Operating Case Temperature	T_C	← -65 to +110 →				°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	← 85 → ← 1.0 →				Watts W/°C
Thermal Resistance Junction to Case	θ_{JC}	1.0				°C/W
Thermal Resistance Case to Ambient	θ_{CA}	32.7				°C/W



MP2060 thru MP2063 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
DC Forward Current Gain (Note 1) (I_C = 3 Adc, V_{CE} = 2 Vdc)		h_{FE}	30	—	150	—
Current Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12 Vdc)		f_T	—	600	—	kc
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	—	—	0.70	Vdc
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2 Vdc)		g_{FE}	3.0	—	—	mhos
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	MP2060	BV_{CES}*	30	—	—	Vdc
	MP2061		45	—	—	
	MP2062		60	—	—	
	MP2063		75	—	—	
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc)	MP2060	$V_{CEO(sus)}$*	25	—	—	Vdc
	MP2061		35	—	—	
	MP2062		40	—	—	
	MP2063		60	—	—	
Collector-Base Breakdown Voltage (I_C = 20 mAdc)	MP2060	BV_{CBO}	40	—	—	Vdc
	MP2061		60	—	—	
	MP2062		75	—	—	
	MP2063		90	—	—	
Collector-Base Cutoff Current (V_{CB} = 2 Vdc)		I_{CBO}	—	—	0.060	mAdc
(V_{CB} = 25 Vdc)	MP2060		—	—	1.0	
(V_{CB} = 35 Vdc)	MP2061		—	—	1.0	
(V_{CB} = 40 Vdc)	MP2062		—	—	1.0	
(V_{CB} = 60 Vdc)	MP2063		—	—	1.0	
Collector-Emitter Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2060	I_{CEX}	—	—	10	mAdc
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2061		—	—	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2062		—	—	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2063		—	—	10	
Emitter-Base Cutoff Current (V_{BE} = 20 Vdc)		I_{EBO}	—	—	1.0	mAdc
Input Impedance (I_C = -500 mAdc, V_{CE} = -12 Vdc, i_b = 1 mAdc, f = 1 kHz)		h_{ie}	—	25	—	ohms
Distortion (I_C = -500 mAdc, V_{CE} = -12 Vdc, R_S = 30 ohms, R_L = 25 ohms, R_E (unbypassed) = 0.33 ohm, P_{out} = 2 watts)		η	—	3.0	—	%

*Sweep Test: 1/2 sine wave, 60 Hz

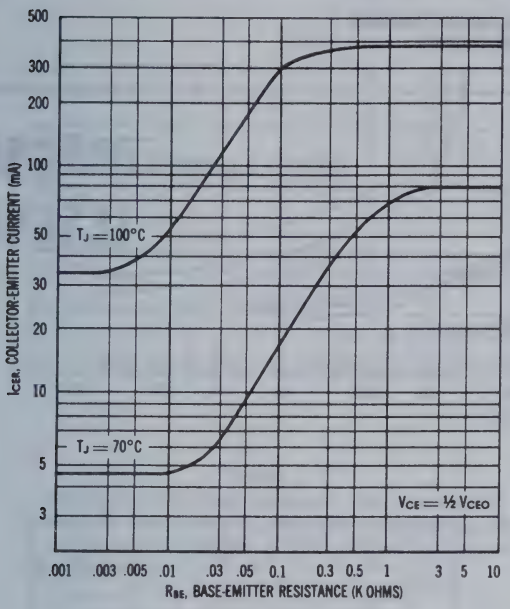
NOTE: upon customer's request the transistors will be numerically coded to identify matched pairs. The dc current transfer ratios are sorted into approximately 1:1.5 ranges. Any two devices within a bracket constitute a matched pair. No guarantee is made of gain distribution.

I_C = 3 Adc, V_{CE} = 2 Vdc

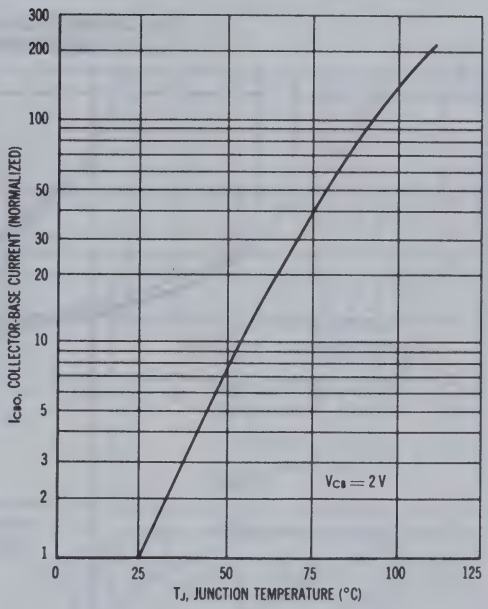
Bracket	h_{FE} Min	h_{FE} Max
-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

MP2060 thru MP2063 (continued)

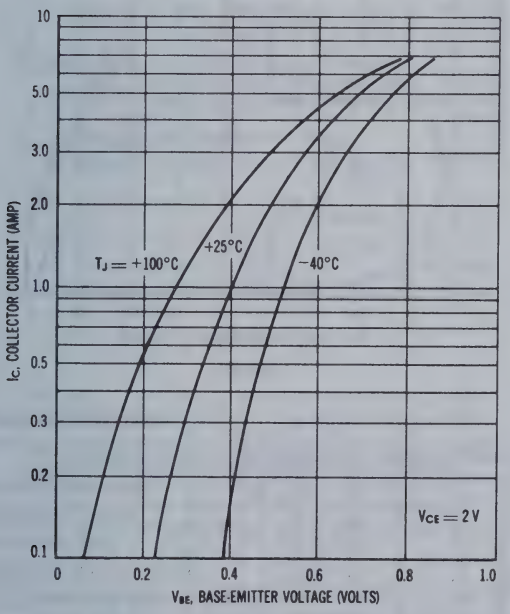
COLLECTOR-EMITTER CURRENT versus BASE-EMITTER RESISTANCE



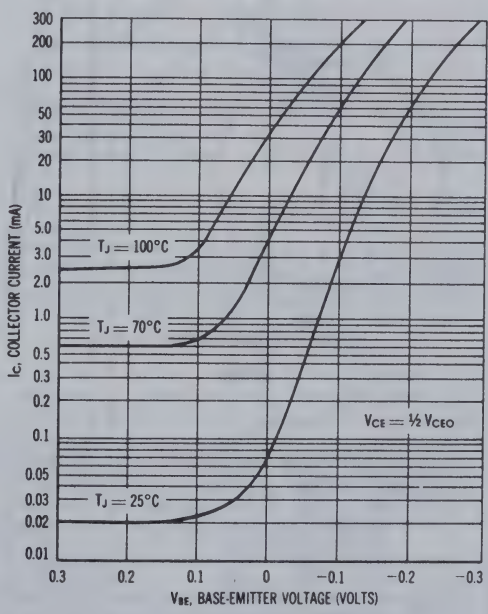
NORMALIZED COLLECTOR-BASE CURRENT



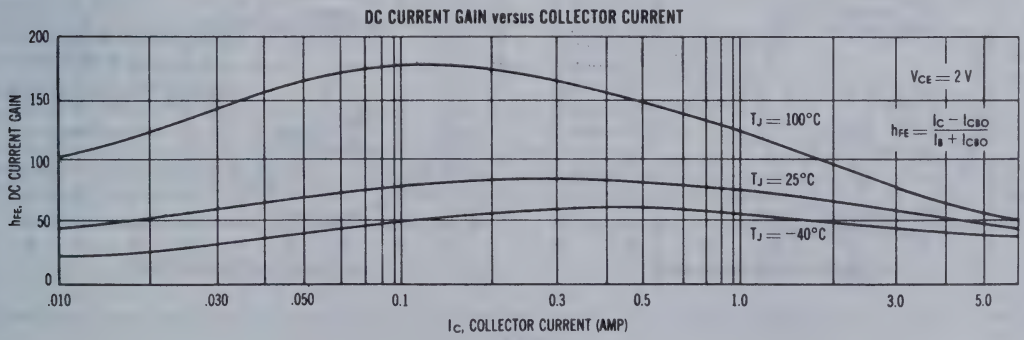
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



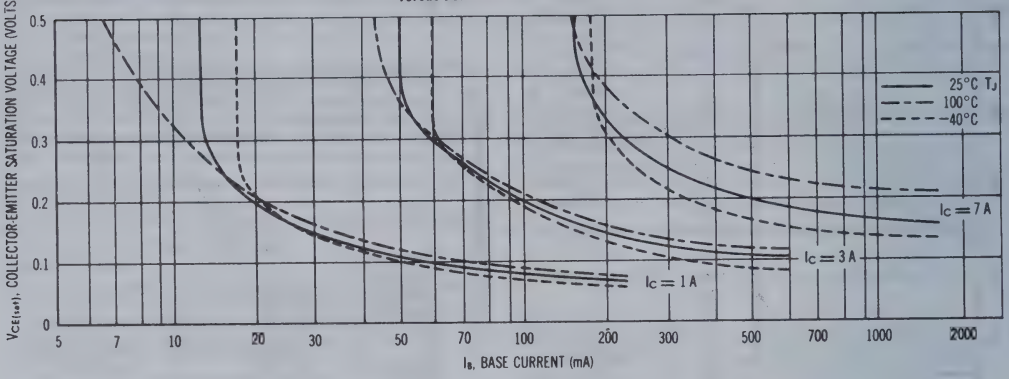
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



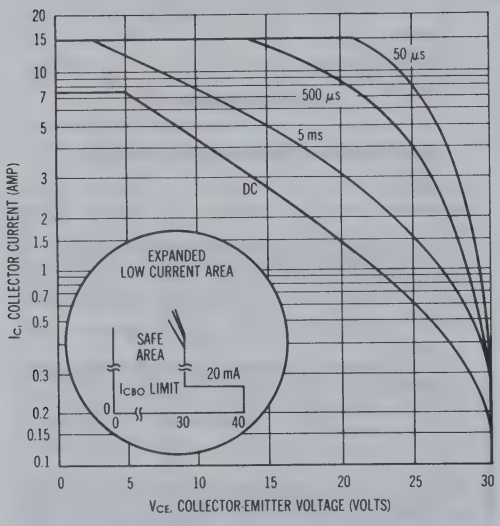
DC CURRENT GAIN versus COLLECTOR CURRENT



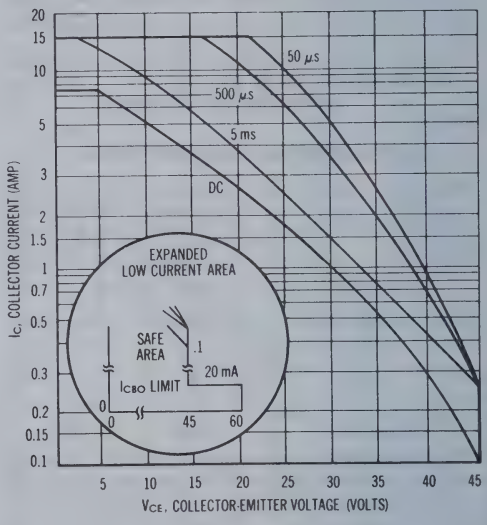
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS
versus JUNCTION TEMPERATURE



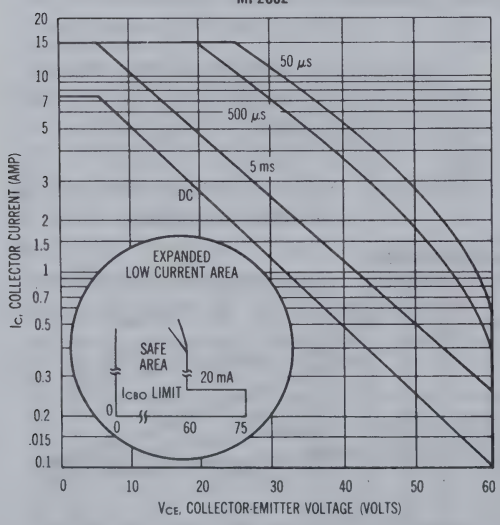
MP2060



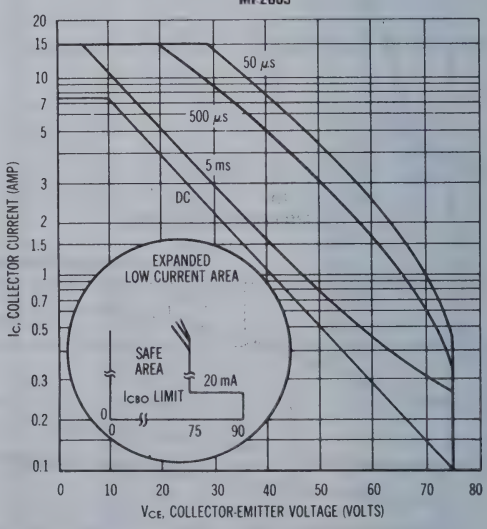
MP2061



MP2062



MP2063



MP2100A, MP2200A, MP2300A, MP2400A

For Specifications, See MP2000A Data.

MP3730 (GERMANIUM)
MP3731

PNP GERMANIUM POWER TRANSISTORS

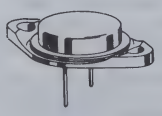
PNP Germanium power transistors with the MP3730 designed primarily for medium-power, vertical deflection amplifier applications in television receivers and the MP3731 designed for horizontal amplifier applications.

- Low Collector Cutoff Current —
  I_{CES} = 5.0 mAdc (Max) @ V_{CE} = 200 Vdc MP3730
  = 10 mAdc (Max) @ V_{CE} = 320 Vdc MP3731
- Low Collector Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 50 mAdc MP3730
  = 0.5 Vdc (Max) @ I_C = 6.0 Adc MP3731
- Low Base-Emitter Saturation Voltage —
  $V_{BE(sat)}$ = 0.8 Vdc (Max) @ I_C = 6.0 Adc MP3731

5 and 10 AMPERE POWER TRANSISTORS

PNP GERMANIUM EPITAXIAL BASE

200-320 VOLTS
56 WATTS

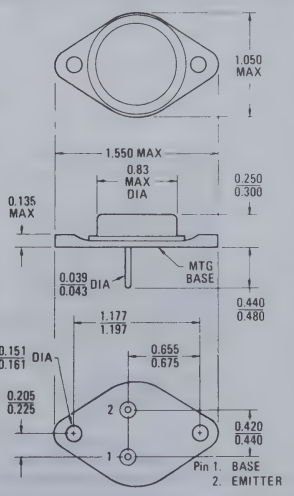


***MAXIMUM RATINGS**

Rating	Symbol	MP3730	MP3731	Unit
Collector-Emitter Voltage	V_{CES}	200	320	Vdc
Collector-Base Voltage	V_{CB}	200	320	Vdc
Emitter-Base Voltage	V_{EB}	2.0		Vdc
Collector Current — Continuous	I_C	5.0	10	Adc
Total Device Dissipation @ T_C = 25°C	P_D	56		Watts
Derate above 25°C		0.67		W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	−65 to +110		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W



All JEDEC dimensions and notes apply

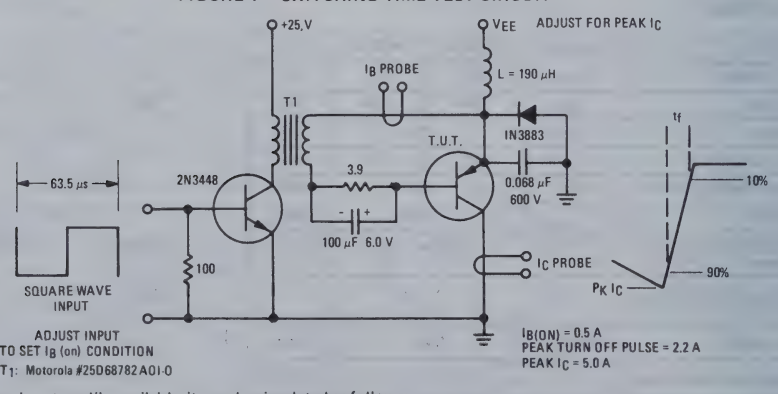
Collector connected to case

CASE 11
TO-3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 200 Vdc, V_{BE} = 0)	MP3730		–	5.0	
(V_{CE} = 320 Vdc, V_{BE} = 0)	MP3731		–	10	
Collector Cutoff Current		I_{CBO}	–	0.4	mAdc
(V_{CB} = 10 Vdc, I_E = 0)					
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 0.5 Vdc, I_C = 0)	MP3730		–	50	
(V_{BE} = 2.0 Vdc, I_C = 0)	MP3731		–	50	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	MP3730		10	200	
(I_C = 2.25 Adc, V_{CE} = 4.0 Vdc)	MP3730		15	–	
(I_C = 6.0 Adc, V_{CE} = 3.0 Vdc)	MP3731		15	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MP3730		–	0.5	
(I_C = 2.25 Adc, I_B = 150 mAdc)	MP3730		–	0.75	
(I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731		–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$	–	0.8	Vdc
(I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731				
Base-Emitter On Voltage		$V_{BE(on)}$	–	0.6	Vdc
(I_C = 0.5 mAdc, V_{CE} = 4.0 Vdc)	MP3730				
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product		f_T	1.0	–	MHz
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)					
SWITCHING CHARACTERISTICS (Figure 1)					
Fall Time – MP3731		t_f	–	2.0	μs
(V_{CE} = 300 V (Peak), I_C = 5.0 A, (Peak)					
I_{B1} = 0.5 A (Peak), I_{B2} = 2.2 A (Peak)					

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



NOTE: If transformer is not readily available, it may be simulated as follows: Material: ¼ inch thick EI stack-laminated soft iron. Center leg ¼ inch by ¼ inch. (No air gap.) Primary: 260 turns No. 30 (AWG) Secondary: 22 turns No. 24 (AWG)

MPC1000 (SILICON)

HIGH POWER NPN SILICON POWER VOLTAGE REGULATOR

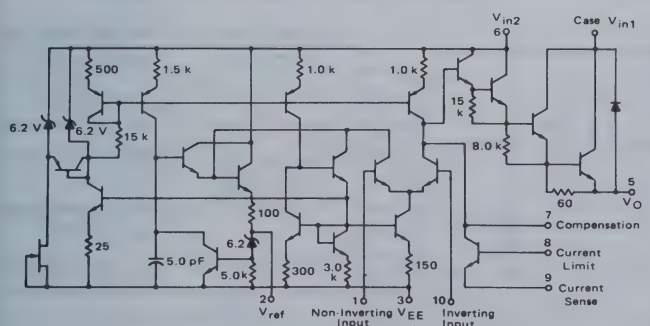
The MPC1000 is a positive or negative voltage regulator designed to deliver load current to 10 Adc. Output current capability can be increased further through use of one or more external pass transistors. The MPC1000 is specified for operation over the military temperature range (-55 to +200°C)

- 100 Watt Power Capability
- Output Voltage Adjustable – 2 to 35 Vdc
- Output Current to 10 Adc Without External Pass Transistors
- 0.1% Line and 0.15% Load Regulation
- Adjustable Short-Circuit Protection

MAXIMUM RATINGS (T_C = +25°C, unless otherwise noted.)

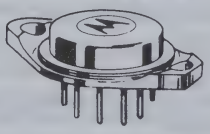
Rating	Symbol	Value	Unit
Pulse Voltage from V_{in2} to V_{EE} (50 ms)	$V_{in2(p)}$	50	V_{peak}
Continuous Voltage from V_{in2} to V_{EE}	V_{in2}	40	Vdc
Input-Output Voltage Differential	V_{in1}-V_O V_{in2}-V_O	60 40	Vdc Vdc
Maximum Output Current	I_L	10	Adc
Current from V_{ref}	I_{ref}	15	mA
Internal Power Dissipation @ T_C = 25°C Derate above T_C = 25°C	P_D $1/\theta_{JC}$	100 0.571	Watts W/°C
Operating Junction Temperature Range	T_J	-55 to 200	°C
Storage Junction Temperature Range	T_{stg}	-65 to 200	°C
Operating Case Temperature Range	T_C	-55 to +175	°C

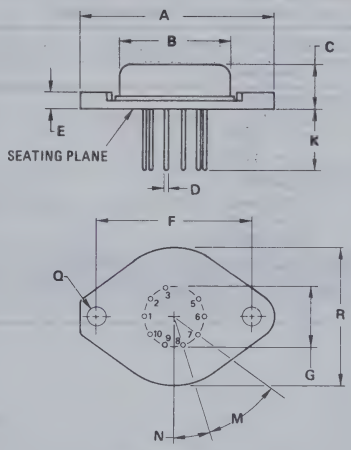
FIGURE 1 – CIRCUIT SCHEMATIC



VOLTAGE REGULATOR

HIGH-CURRENT NPN SILICON





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	38.61	–	1.520
B	–	21.03	–	0.830
C	6.35	8.13	0.250	0.320
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	11.94 BSC		0.470 BSC	
K	7.11	8.13	0.280	0.320
M	36° BSC		36° BSC	
N	18° BSC		18° BSC	
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION.

CASE 662-01

SOCKET/WASHER NOTE:
Mica Insulating Washer: Electronic Essentials Part No. MI-9-1000

Socket: Electronic Essentials
Part No. MS-9-1000
Electronic Essentials, Inc.
49 Bleeker Street
New York, New York 10012

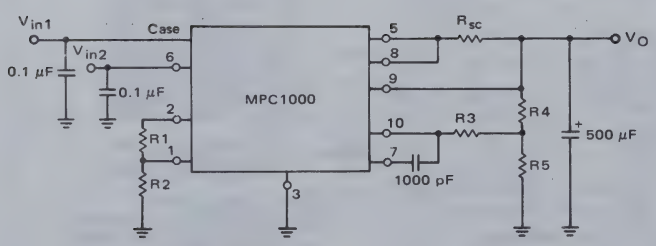
ELECTRICAL CHARACTERISTICS (T_C = 25°C, $V_{in1} = V_{in2}$ = 12 Vdc, V_{EE} = 0, V_O = 5.0 Vdc, I_L = 10 mAdc, unless otherwise noted.)

Characteristics	Figure No.	Note	Symbol	Min	Max	Units
Input Voltage Range	2	1	V_{in2}	9.5	40	Vdc
Output Voltage Range	2	–	V_O	2.0	35	Vdc
Input-Output Voltage Differential	2	2	V_{in1}-V_O V_{in2}-V_O	3.0 5.0	60 38	Vdc Vdc
Reference Voltage	2	3	V_{ref}	6.8	7.5	Vdc
Standby Current Drain (I_L = 0, $V_{in1} = V_{in2}$ = 30 Vdc, V_O = 5.0 Vdc)	2	8	I_{IB}	–	5.0	mAdc
Line Regulation ($V_{in1} = V_{in2}$ = 12 Vdc to 15 Vdc) ($V_{in1} = V_{in2}$ = 12 Vdc to 40 Vdc)	 2 2	 2,6 2,6	 Reg_{in} Reg_{in}	 – –	 0.1 0.5	 %V_O %V_O
Load Regulation (I_L = 100 mAdc to I_L = 4.0 Adc, pulsed)	2	2,4,7	Reg_{load}	–	0.15	%V_O

TEMPERATURE PERFORMANCE (I_L = 10 mAdc, V_O = 5.0 Vdc, V_{EE} = 0, unless otherwise noted.)

Characteristic	Figure	Note	Symbol	Typ	Units
Line Regulation ($V_{in1} = V_{in2}$ = 12 Vdc to 15 Vdc) T_C = -55°C T_C = +125°C	2	2,6	Reg_{in}	 0.5 0.5	 %V_O %V_O
Load Regulation (I_L = 100 mAdc to 4.0 Adc, $V_{in1} = V_{in2}$ = 12 Vdc) T_C = -55°C T_C = +125°C	2	2,4,7	Reg_{load}	 0.6 0.6	 %V_O %V_O
Temperature Coefficient of Output Voltage ($V_{in1} = V_{in2}$ = 12 Vdc, I_L = 1.0 Adc, ΔT_C = 180°C, T_C = -55°C to +125°C)	2	2,4,5	T_{CVO}	0.005	$\frac{\%V_O}{°C}$

FIGURE 2 – TYPICAL CIRCUIT CONNECTION



PARAMETER VALUES FOR BEST RESULTS

	2 V < V_O < 7 V	7 V < V_O < 35 V
R1	$\cong \frac{R2\ (7 - V_O)}{V_O}$	$= \left[\frac{R4\,R5}{R4 + R5}\right]$
R2	10 k < R1 + R2 < 100 k	∞
R3	$= \left[\frac{R1\,R2}{R1 + R2}\right]$	0
R4	0	$\cong \frac{R5\ (V_O - 7)}{7}$
R5	∞	10 k < R5 < 100 k
R_{sc}	$\cong \frac{0.66}{I_{sc}}$ @ T_J = 25°C	

1. "Minimum Input Voltage" is the minimum "total instantaneous input voltage" required to properly bias the internal zener reference diode.
2. Set R_{sc} = 0 (short circuit)
3. V_{ref} voltage is measured from Pin 2 to Pin 3.
4. Pulse test conditions: Load current must be switched from minimum to maximum value at a repetition rate of 10 pps or less with a duty cycle of 1% or less in order to minimize heating effects.
5. The temperature coefficient of output voltage is defined as:

$$T_{CVO} = \frac{\pm(V_{O\ max} - V_{O\ min})\ (100)}{(\Delta T_C)\ (V_O\ @\ T_C = 25^oC)}$$

6. The input line regulation is defined as:

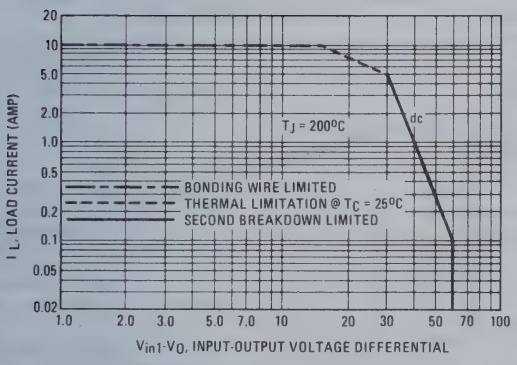
$$Reg_{in} = \frac{\pm\ (V_O\ @\ V_{in\ high} - V_O\ @\ V_{in\ low})}{V_O\ @\ V_{in\ low}} \times 100$$

7. Load regulation is defined as:

$$Reg_{load} = \frac{\pm\ (V_O\ @\ I_{Llow} - V_O\ @\ I_{Lhigh})\ (100)}{(V_O\ @\ I_{Llow})}$$

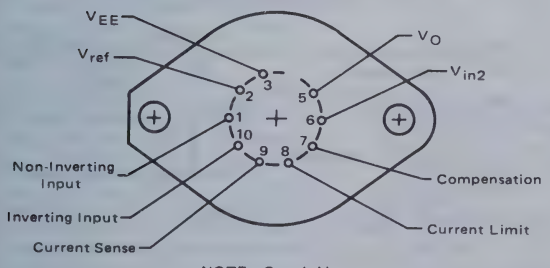
8. Standby current drain is defined as that value of current measured at Pins 6 and Case when R_L is open circuited.

FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a power semiconductor: average junction temperature and second breakdown. Safe operating area curves indicate I_L, ($V_{in1} - V_O$) limits of the circuit that must be observed for reliable operation;

FIGURE 4 – PIN CONNECTION – BOTTOM VIEW



NOTE: Case is V_{in1}

FIGURE 5 – CURRENT LIMITING CHARACTERISTICS

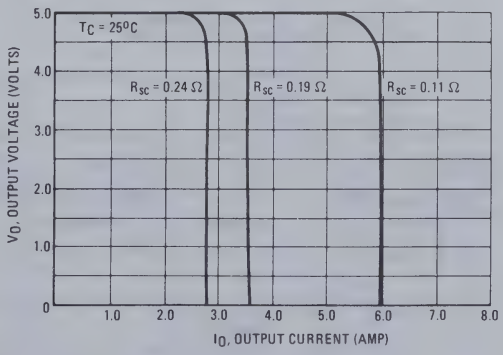


FIGURE 6 – LINE REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL

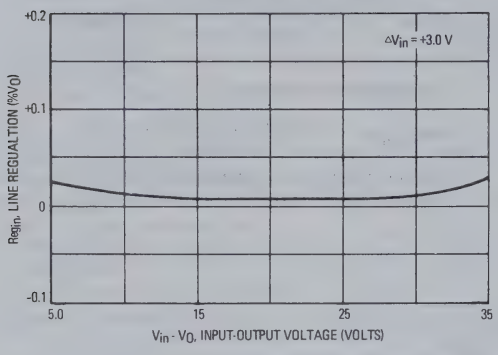


FIGURE 7 – STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE

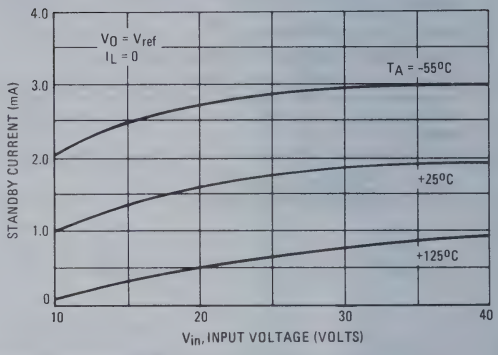


FIGURE 8 – LOAD TRANSIENT RESPONSE

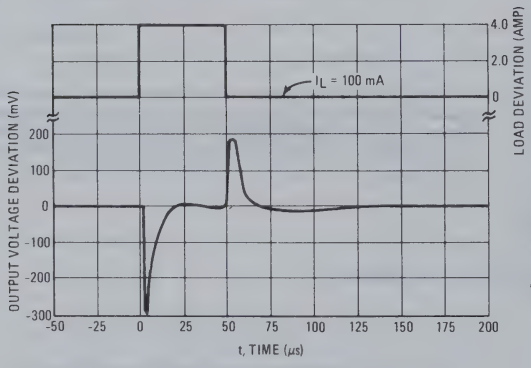


FIGURE 9 – LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING

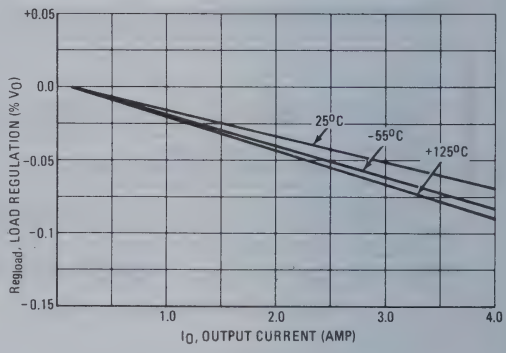


FIGURE 10 – 5 VOLT, 10 AMPERE HIGH EFFICIENCY REGULATOR

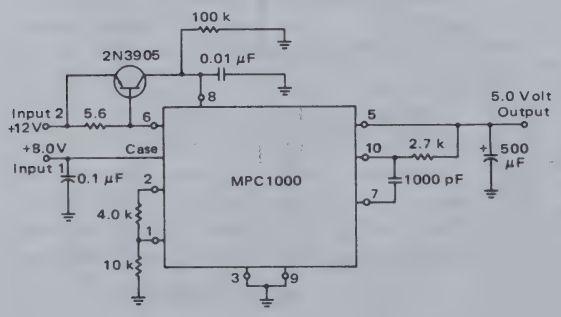
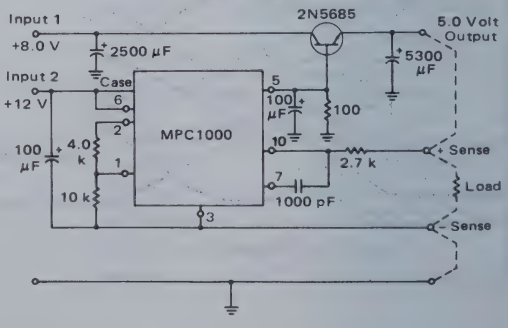


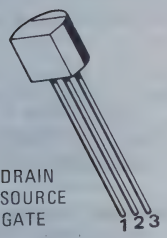
FIGURE 11 – 5 VOLT, 50 AMPERE POWER REGULATOR WITH REMOTE SENSE



Regulator is protected by current limiting if input 1 is removed.

MPF102 (SILICON)

Silicon N-channel junction field-effect transistor designed for VHF amplifier and mixer applications.



CASE 29 (5)
(TO-92)

Drain and Source may be interchanged

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	BV_{GSS}	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100 C)	I_{GSS}	— —	2.0 2.0	nAdc μAdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	8.0	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	0.5	7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	$\lvert y_{fs} \rvert$	2000	7500	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	3.0	pF
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert y_{fs} \rvert$	1600	—	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

MPF108 (SILICON)

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

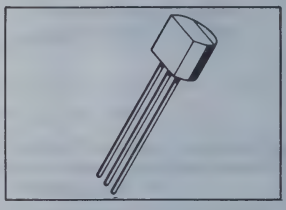
Depletion mode (Type A) transistor designed for VHF amplifier and mixer applications.

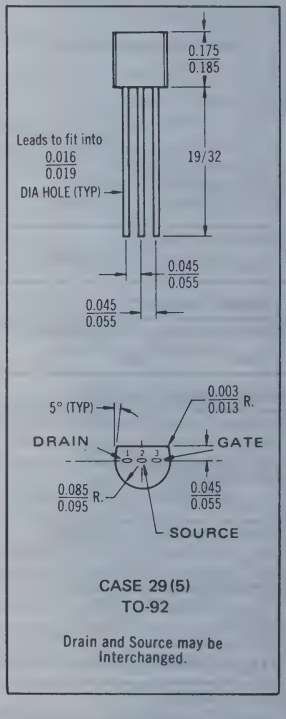
- Devices are Classified and Identified in 2:1 I_{DSS} Ranges
- Low Cross-Modulation and Intermodulation Distortion
- Guaranteed 100 MHz Parameters
- Drain and Source Interchangeable
- Low Transfer and Input Capacitance —
  C_{rss} = 1.2 pF (Typ) @ V_{DS} = 15 Vdc
  C_{iss} = 5.0 pF (Typ) @ V_{DS} = 15 Vdc
- Low Leakage Current
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

SYMMETRICAL SILICON N-CHANNEL

Type A





CASE 29(5)
TO-92

Drain and Source may be Interchanged.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.5	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)		-	-1.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	2000	7500	μmhos
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	1600	-	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	-	200	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	-	800	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	6.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.5	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 k ohm, f = 100 MHz)		-	3.0	

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DSS}	$V_{GS(off)}$	y_{fs}
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μmhos

MPF109 (SILICON)

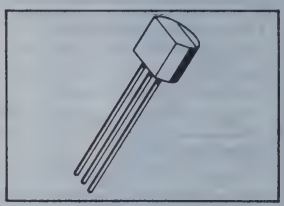
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

Depletion mode transistor designed for general-purpose audio and switching applications.

- Devices are Classified and Identified in 2:1 Zero-Gate Voltage Drain Current Ranges (2:1 I_{DSS} Ranges)
- Drain and Source Interchangeable
- High AC Input Impedance
- High DC Input Resistance
- Low Transfer and Input Capacitance
- Low Cross-Modulation and Intermodulation Distortion
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

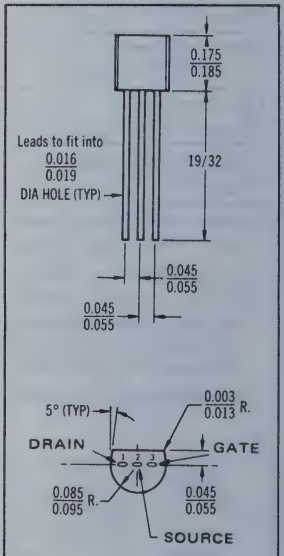
SYMMETRICAL SILICON N-CHANNEL



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	m Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29(5)
TO-92

Drain and Source may be Interchanged

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	-1.0	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	0.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	800	6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{os}	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	3.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DSS}	$V_{GS(off)}$	y_{fs}
White	0.5 mAdc Min, 1.0 mAdc Max	0.2 Vdc Min, 2.0 Vdc Max	800 to 3200 μmhos
Red	0.8 mAdc Min, 1.6 mAdc Max	0.4 Vdc Min, 4.0 Vdc Max	1000 to 4000 μmhos
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.4 Vdc Min, 4.0 Vdc Max	1000 to 4000 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	1.0 Vdc Min, 6.0 Vdc Max	1500 to 5000 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 6.0 Vdc Max	1500 to 5000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	2000 to 6000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	2000 to 6000 μmhos

MPF111 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode device designed for general-purpose amplifier and switching applications.

- Low Transfer Capacitance – C_{rss} = 1.5 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance – C_{iss} = 4.5 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package
- Drain and Source Interchangeable

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR



MAXIMUM RATINGS

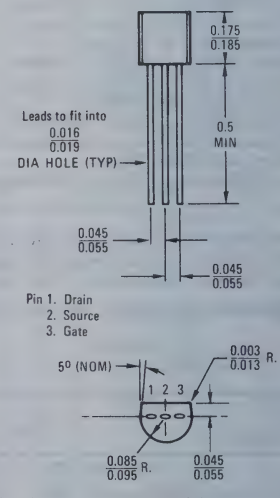
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	-20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (2)	200 2.0	mW mW/°C
Operating Junction Temperature	T_J (2)	125	°C
Storage Temperature Range	T_{stg}	-65 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-20	-35	–	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	–	0.1	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	-4.0	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	0.5	8.0	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{fs}\|$	500	3000	–	μmhos
Output Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|Y_{os}\|$	–	20	–	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.5	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.5	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

(2) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

MPF112 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) device designed for VHF amplifier and mixer applications.

- Low Cross-Modulation Distortion
- Low Transfer Capacitance – C_{rss} = 3.0 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance – C_{iss} = 8.0 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR



MAXIMUM RATINGS

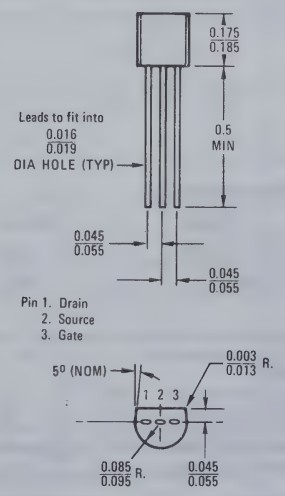
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (2)	200 2.0	mW mW/°C
Operating Junction Temperature	T_J (2)	125	°C
Storage Temperature Range	T_{stg}	-65 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-25	–	–	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	–	–	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	–	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	1.0	–	25	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz) ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert Y_{fs} \rvert$	1000 800	– –	7500 –	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	8.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	3.0	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

(2) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C – Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

MPF130, MPF131, MPF132 (SILICON)
MFE130, MFE131, MFE132

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

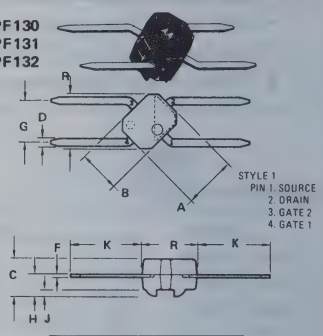
- MPF130/MFE130 – RF Amplifier @ 105 MHz
  MPF131/MFE131 – RF Amplifier @ 60 and 200 MHz
  MPF132/MFE132 – Mixer @ 60 and 200 MHz
- Silicon Nitride Passivation for Excellent Long Term Stability
- Diode Protected Gates
- Supplied in Metal Can or Plastic Packages –
  MFE130 Series – TO-72
  MPF130 Series – Case 262

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain Current	I_D	30		mAdc
		MPF130 Series	MFE130 Series	
Total Power Dissipation @ $T_A = 25^oC$ (Package Limitation)	P_D	350	300	mW
Derate above 25^oC		2.33	1.71	$mW/^oC$
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +175	-65 to +200	^oC

N-CHANNEL DUAL GATE MOS FIELD – EFFECT TRANSISTORS

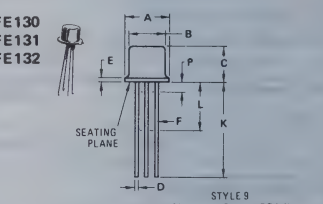
MPF130
MPF131
MPF132



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.95	5.21	0.195	0.205
B	3.94	4.19	0.155	0.165
C	2.67	2.92	0.105	0.115
D	0.64	0.89	0.025	0.035
F	0.20	0.30	0.008	0.012
G	4.06 BSC		0.160 BSC	
H	1.57	1.83	0.062	0.072
J	0.51	0.76	0.020	0.030
K	6.35	7.62	0.250	0.300
R	5.21	5.46	0.205	0.215

CASE 262-02

MFE130
MFE131
MFE132



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) Substrate Connected to Source

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = -4.0 Vdc, V_{G2} = +4.0 Vdc)	$V_{(BR)DSX}$	25	–	–	Vdc
Gate 1 – Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G1SO}$	±7.0	–	±20	Vdc
Gate 2 – Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)	$V_{(BR)G2SO}$	±7.0	–	±20	Vdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)	$V_{G1S(off)}$	–	–	–4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)	$V_{G2S(off)}$	–	–	–4.0	Vdc
Gate 1 Reverse Leakage Current (V_{G1S} = ±6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	–	–	20	nAdc
Gate 2 Reverse Leakage Current (V_{G2S} = ±6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	–	–	20	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	Y_{fs}	8000	–	20,000	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{iss}	–	4.5	7.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	C_{oss}	–	2.5	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)	C_{rss}	–	0.023	0.05	pF
Common-Source Noise Figure (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)	NF				dB
(f = 105 MHz) MPF/MFE130		–	2.9	5.0	
(f = 60 MHz) MPF/MFE131		–	2.5	5.0	
(f = 200 MHz) MPF/MFE131		–	3.0	5.0	
Common-Source Power Gain (Figure 7) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)	G_{ps}				dB
(f = 105 MHz) MPF/MFE130		17	23	–	
(f = 60 MHz) MPF/MFE131		20	27	–	
(f - 200 MHz) MPF/MFE131		17	20	–	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)	–	–	100	–	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 8). (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms)	G_c				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz) MPF/MFE132		15	16.5	–	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz) MPF/MFE132		12	14	–	

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 – INPUT ADMITTANCE

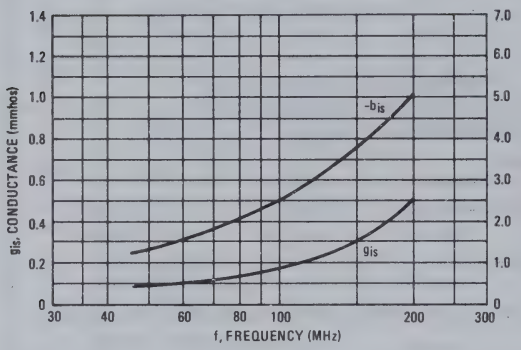


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

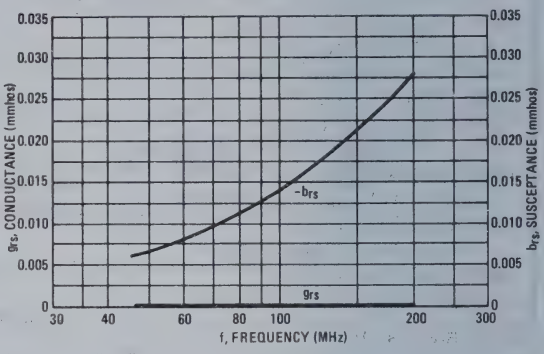


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

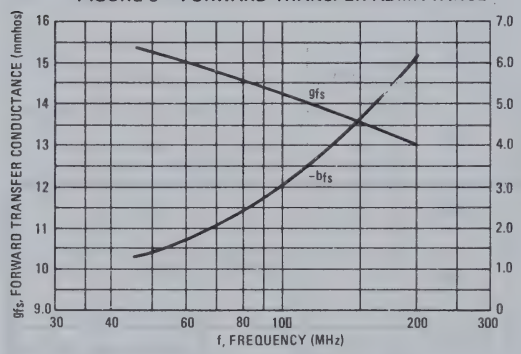


FIGURE 4 – OUTPUT ADMITTANCE

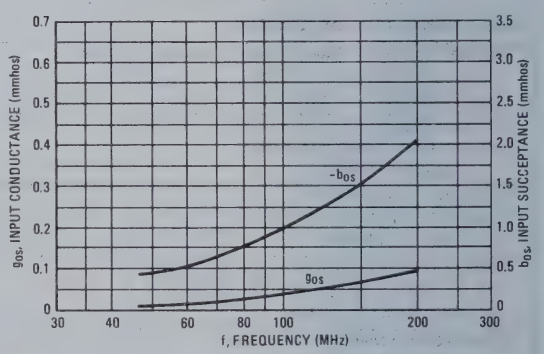


FIGURE 5 – GAIN REDUCTION

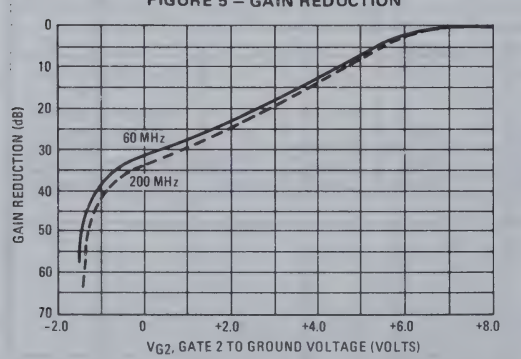


FIGURE 6 – CONVERSION POWER GAIN

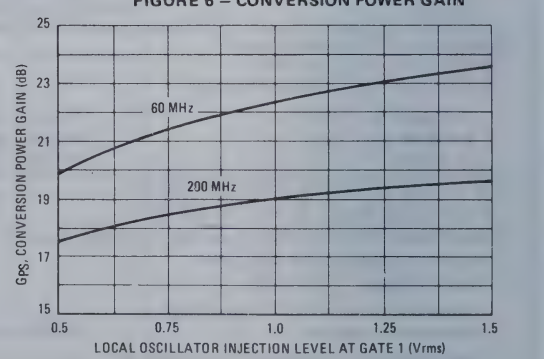
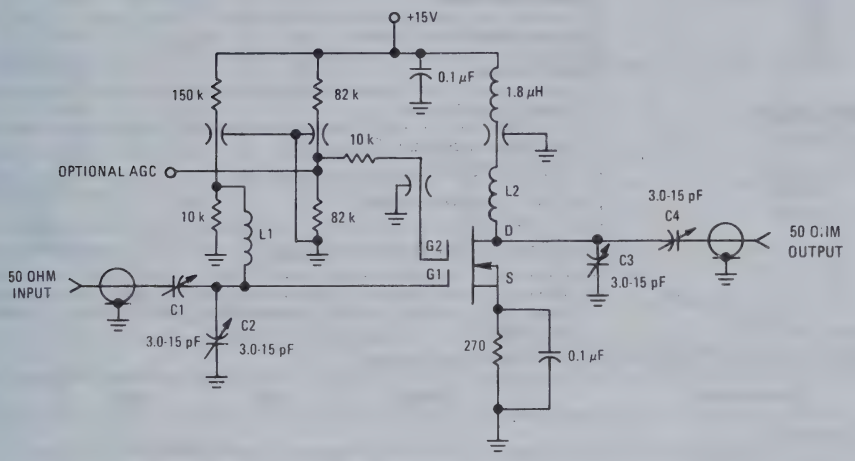


FIGURE 7 – 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

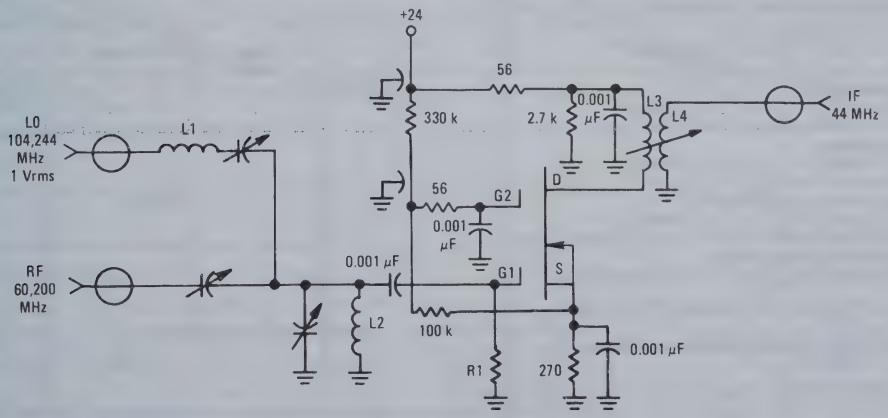


	L1	L2
60 MHz	0.33 μH	0.47 μH
105 MHz	#16 AWG, 6 1/2 Turns, 1" Long, 1/4" Dia.	#16 AWG, 5 1/4 Turns, 1" Long, 7/16" Dia.
200 MHz	#16 AWG, 3 1/2 Turns, 0.7" Long, 0.2" Dia.	#16 AWG, 4 1/2 Turns, 0.65" Long, 0.2" Dia.

All Feedthrough Capacitors 1000 pF

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF

FIGURE 8 – 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT



	R1	L1	L2	L3	L4
60 MHz	10 k	10 Turns #22 Enameled on MILLER 4500-4 Core	0.33 μH DELEVAN	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3
200 MHz	1.0 k	3 1/2 Turns #18, 1/4" Dia., 1/2" Long	2 1/2 Turns #18, 3/8" Dia., 1/2" Long	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3

All Feedthrough Capacitors 1000 pF.

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF.

MPF161 (SILICON)

P-channel junction field-effect transistors depletion mode (Type A) designed for general-purpose amplifier applications.



CASE 29 (7)
(TO-92)

PIN 1. SOURCE
2. DRAIN
3. GATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)	I_{GSS}	-	10	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	0.5	14	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$*	800	6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 1.0 kHz, BW = 1.0 Hz)	NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)	e_n	-	115	$nV/\sqrt{Hz}$

*To characterize these devices to narrower limits, regarding $V_{GS(off)}$, I_{DSS} and $|y_{fs}|$, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	$V_{GS(off)}$	I_{DSS}	$\|y_{fs}\|$
White	0.2 Vdc Min, 2.0 Vdc Max	0.5 mAdc Min, 1.0 mAdc Max	800 to 3200 μmhos
Red	0.4 Vdc Min, 4.0 Vdc Max	0.8 mAdc Min, 1.6 mAdc Max	1000 to 4000 μmhos
Orange	0.4 Vdc Min, 4.0 Vdc Max	1.5 mAdc Min, 3.0 mAdc Max	1000 to 4000 μmhos
Yellow	1.0 Vdc Min, 6.0 Vdc Max	2.5 mAdc Min, 5.0 mAdc Max	1500 to 5000 μmhos
Green	1.0 Vdc Min, 6.0 Vdc Max	4.0 mAdc Min, 8.0 mAdc Max	1500 to 5000 μmhos
Blue	2.0 Vdc Min, 8.0 Vdc Max	7.0 mAdc Min, 14 mAdc Max	2000 to 6000 μmhos

DRAIN CURRENT versus GATE-SOURCE VOLTAGE

FIGURE 1

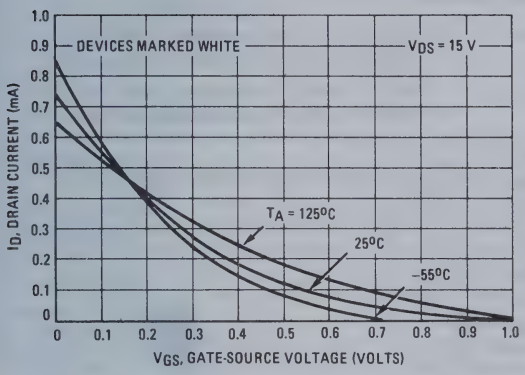


FIGURE 2

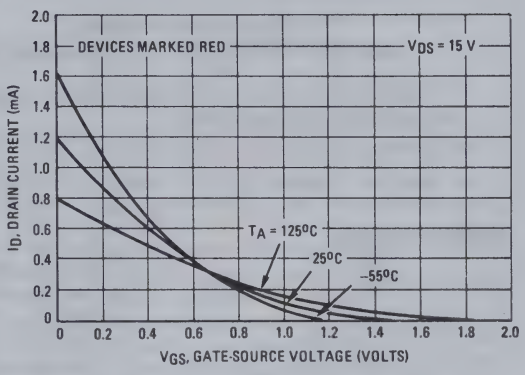


FIGURE 3

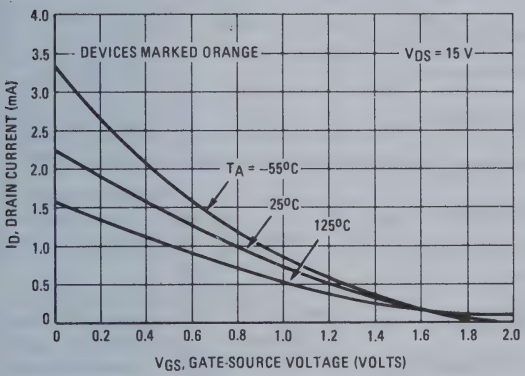


FIGURE 4

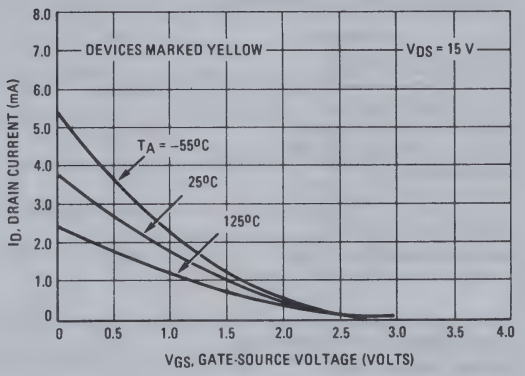


FIGURE 5

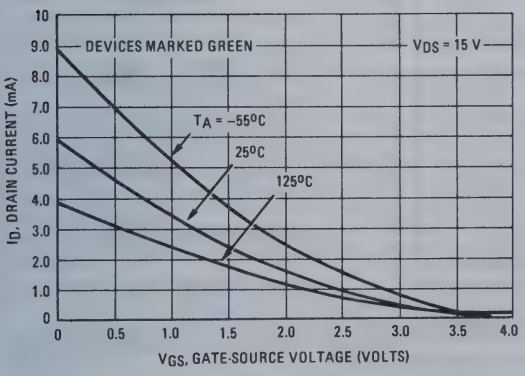
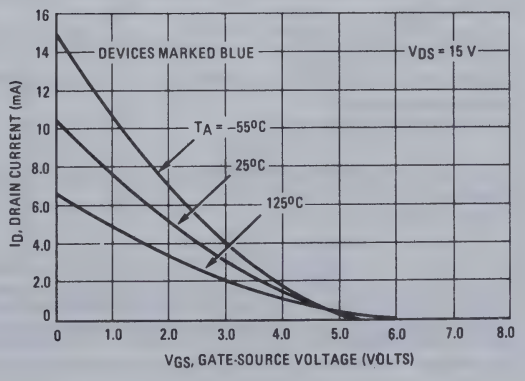


FIGURE 6



MPF256 (SILICON)

Advance Information

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

. . . depletion mode junction field-effect transistor designed for low noise general amplifier applications.

- Low Noise – Less Than 2.0 dB at 100 MHz, 4.0 dB at 400 MHz.
- High Gain – Typically 21 dB at 100 MHz, 12 dB at 400 MHz.

JUNCTION FIELD-EFFECT TRANSISTOR
SILICON N-CHANNEL



MAXIMUM RATINGS

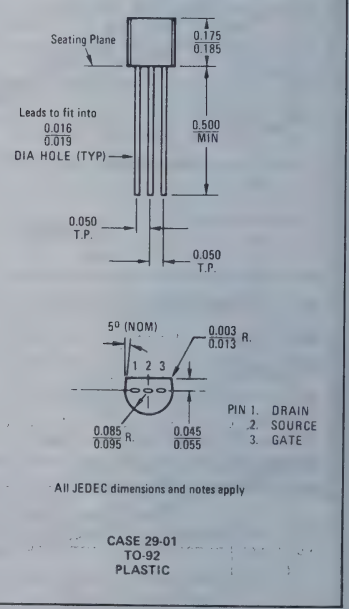
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)	$V_{GS(off)}$	0.5	–	7.5	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	–	–	5.0	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0) Red	I_{DSS}*	3.0	–	7.0	mAdc
Green		6.0	–	13	
Violet		11	–	18	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	Y_{fs}	6.0	–	–	mmhos
Output Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	C_{oss}	–	2.0	–	pF
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{iss}	–	3.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	–	1.2	–	pF
Small-Signal Power Gain (V_{DS} = 15 Vdc, R_S = 50 Ohms)	G_{ps}				dB
100 Mhz		20	–	–	
400 MHz		12	–	–	
Noise Figure (V_{DS} = 15 Vdc, R_S = 50 Ohms)	NF				dB
100 MHz		–	–	2.0	
400 MHz		–	–	4.0	

*To characterize these devices to narrower limits, the entire production lot is tested and divided into color-coded groups, with each color dot representing an I_{DSS} range.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.



All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

This is advance information on a new introduction and specifications are subject to change without notice.

ADI-162

MPF820 (SILICON)

Advance Information

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

. . . depletion mode junction field-effect transistor designed for low noise grounded gate RF amplifier applications.

- Low Noise — Less Than 4.0 dB at 100 MHz
- High Gain — Typically 18 mmhos at 100 MHz

JUNCTION FIELD-EFFECT TRANSISTOR

SILICON N-CHANNEL

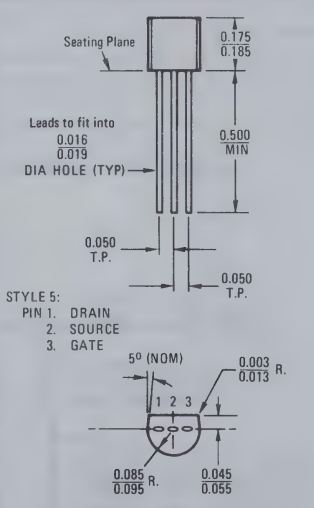


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^{o}C

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc, V_{DS} = 0$)	$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 200\ \mu Adc$)	$V_{GS(off)}$	–	–	5.0	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	–	–	5.0	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	10	–	–	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	Y_{fs}	–	20	–	mmhos
Output Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	C_{oss}	–	3.5	–	pF
Input Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{iss}	–	15	–	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{rss}	–	3.5	–	pF
Common-Gate Input Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	g_{ig}	–	16	–	mmhos
Common-Gate Output Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	g_{og}	–	–	16	μmhos
Common-Gate Forward Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	Y_{fg}	–	18	–	mmhos
Common-Gate Reverse Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	Y_{rg}	–	–	130	μmhos
Small-Signal Power Gain ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	G_{pg}	–	11	–	dB
Noise Figure ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	NF	–	–	4.0	dB



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

This is advance information on a new introduction and specifications are subject to change without notice.

FIGURE 1 – NOISE FIGURE

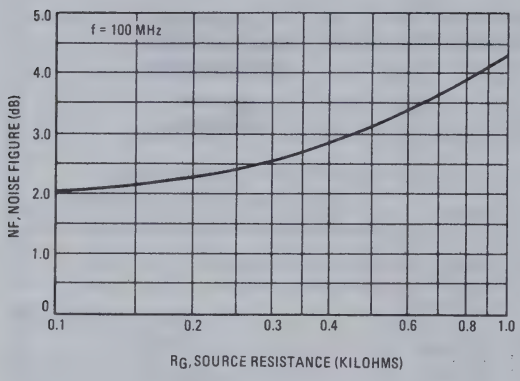


FIGURE 2 – FORWARD TRANSADMITTANCE

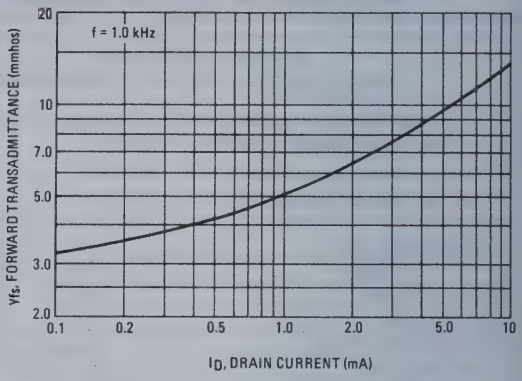


FIGURE 3 – INPUT CAPACITANCE

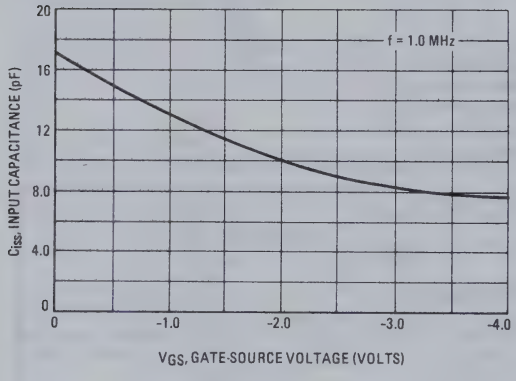


FIGURE 4 – OUTPUT AND REVERSE TRANSFER CAPACITANCE

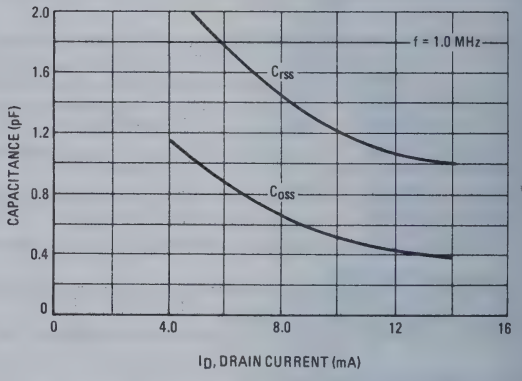
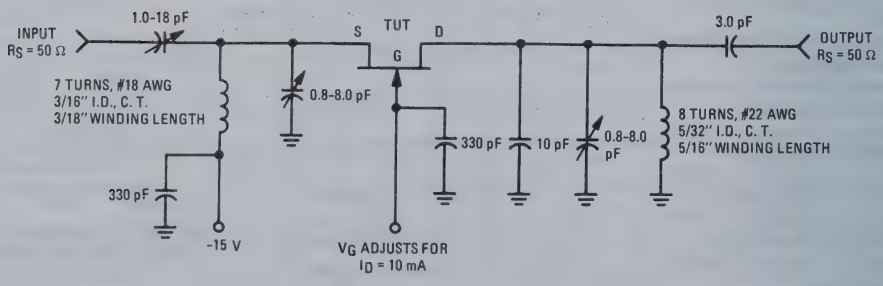


FIGURE 5 – 100 MHz TEST CIRCUIT



MPF970 (SILICON)
MPF971

SILICON P-CHANNEL
JUNCTION FIELD–EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

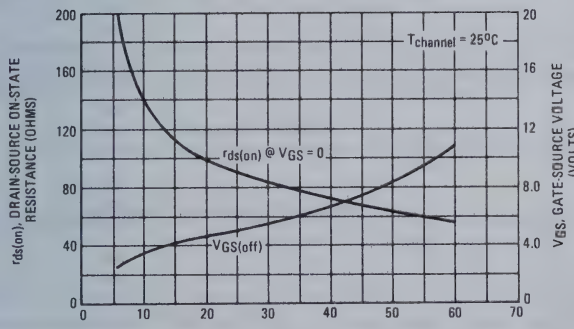
P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Storage Temperature Range	T_{stg}	−65 to +150	^oC
Operating Temperature Range	$T_{channel}$	−65 to +150	^oC



FIGURE 1 – EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



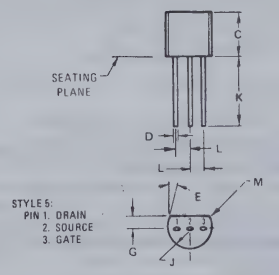
The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 1 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 1. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF970

The electrical characteristics table indicates that an MPF970 has an I_{DSS} range of 15 to 60 mA. Figure 1 shows $r_{ds(on)}$ = 110 Ohms for I_{DSS} = 15 mA and 56 Ohms for I_{DSS} = 60 mA. The corresponding V_{GS} values are 4.1 volts and 10.8 volts.



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	50° NOM		50° NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330

CASE 29-01
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	MPF970	$V_{GS(off)}$	5.0	–	12	Vdc
	MPF971		1.0	–	7.0	
Gate Reverse Current		I_{GSS}				
(V_{GS} = 15 Vdc, V_{DS} = 0)			–	–	1.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			–	–	1.0	μAdc
Drain-Cutoff Current		$I_{D(off)}$				
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)	MPF970		–	–	10	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)	MPF970		–	–	10	μAdc
(V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc)	MPF971		–	–	10	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	MPF971		–	–	10	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (1) (V_{DS} = 20 Vdc, V_{GS} = 0)	MPF970	I_{DSS}	15	–	60	mAdc
	MPF971		2.0	–	30	
Drain-Source "ON" Voltage		$V_{DS(on)}$				Vdc
(I_D = 10 mAdc, V_{GS} = 0)			–	–	1.5	
(I_D = 1.5 mAdc, V_{GS} = 0)			–	–	1.5	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MPF970	$r_{DS(on)}$	–	–	100	Ohms
	MPF971		–	–	250	
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF970	$r_{ds(on)}$	–	–	100	Ohms
	MPF971		–	–	250	
Input Capacitance		C_{iss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)	MPF970		–	–	12	
(V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	MPF971		–	–	12	
Reverse Transfer Capacitance		C_{rss}				pF
(V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)	MPF970		–	–	5.0	
(V_{GS} = 7.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	MPF971		–	–	5.0	
SWITCHING CHARACTERISTICS (See Figure 6, R_K = 0) (1)						
Turn-On Time		t_{on}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		–	3.5	8.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		–	5.0	10	
Rise Time		t_r				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		–	2.0	5.0	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		–	3.0	5.0	
Turn-Off Time		t_{off}				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		–	13	25	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		–	88	120	
Fall Time		t_f				ns
($I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MPF970		–	9.0	15	
($I_{D(on)}$ = 1.5 mAdc, $V_{GS(off)}$ = 7.0 Vdc)	MPF971		–	68	80	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

FIGURE 2 – TURN-ON DELAY TIME

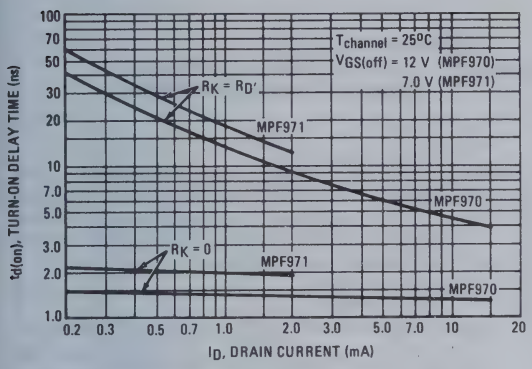


FIGURE 3 – RISE TIME

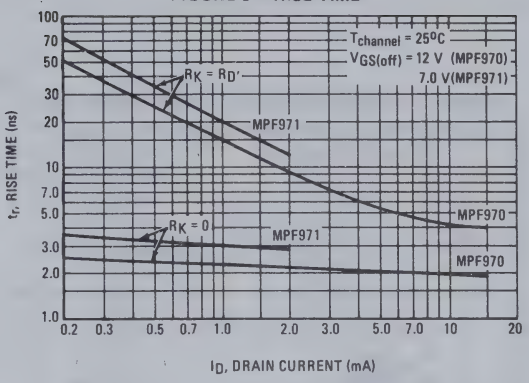


FIGURE 4 – TURN-OFF DELAY TIME

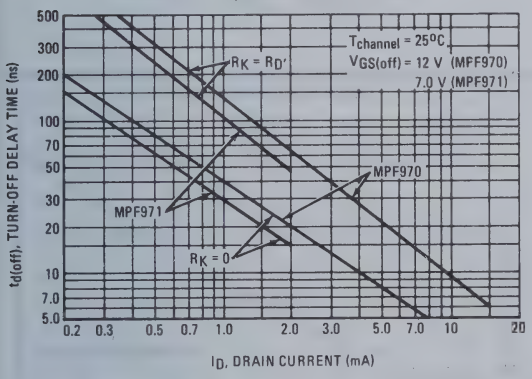


FIGURE 5 – FALL TIME

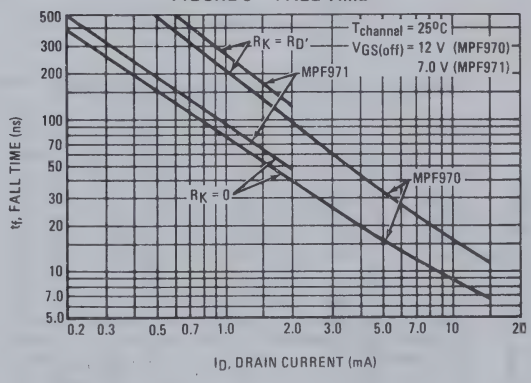
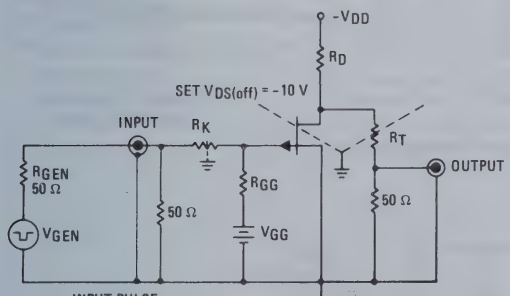


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($+V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) R_K = 0 (low impedance) the driving source impedance is that of the generator.

FIGURE 7 – TYPICAL FORWARD TRANSFER ADMITTANCE

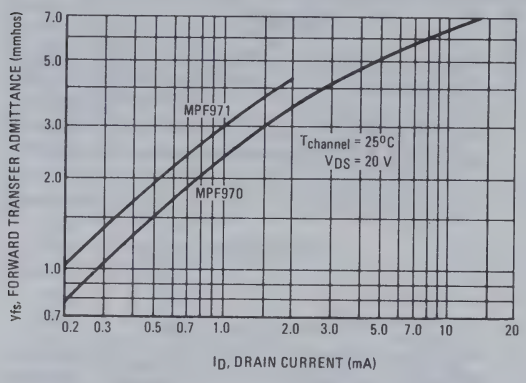


FIGURE 8 – TYPICAL CAPACITANCE

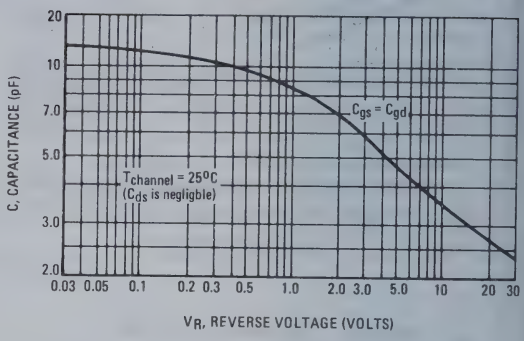


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

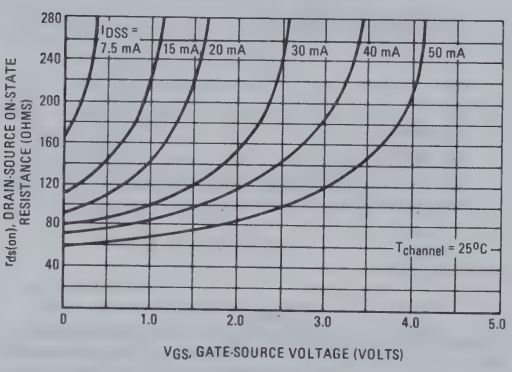


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

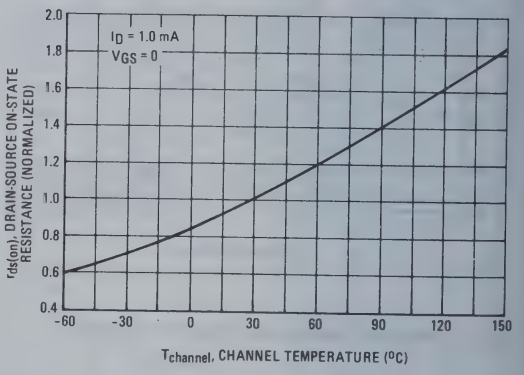
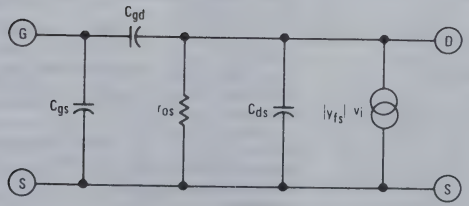


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}$, $C_{ds} \approx 0$

MPF4391, MPF4392, MPF4393 (SILICON)

SILICON N-CHANNEL
JUNCTION FIELD–EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

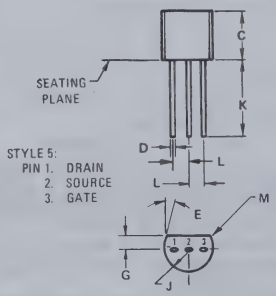
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 30 Ohms (Max) – MPF4391
  = 60 Ohms (Max) – MPF4392
  = 100 Ohms (Max) – MPF4393
- Low Reverse Transfer Capacitance –
  C_{rss} = 3.5 pF (Max)
- Guaranteed Fast Switching Times –
  t_{on} = 15 ns (Max) – All Types
  t_{off} = 20 ns (Max) – MPF4391
  = 35 ns (Max) – MPF4392
  = 55 ns (Max) – MPF4393

N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +150	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
C	4.450	4.700	0.175	0.185
D	0.407	0.482	0.016	0.019
E	5° NOM		5° NOM	
G	1.150	1.390	0.045	0.055
J	2.160	2.420	0.085	0.095
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
M	0.076	0.330	0.003	0.013

CASE 29(5)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	MPF4391	V_{GS}	4.0	–	10	Vdc
	MPF4392		2.0	–	5.0	
	MPF4393		0.5	–	3.0	
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	–	–	1.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)			–	–	0.2	μAdc
Drain-Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)		$I_{D(off)}$	–	–	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 100°C)			–	–	0.1	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	MPF4391	I_{DSS}	60	–	130	mAdc
	MPF4392		25	–	75	
	MPF4393		5.0	–	30	
Drain-Source "ON" Voltage (I_D = 12 mAdc, V_{GS} = 0)	MPF4391	$V_{DS(on)}$	–	–	0.4	Vdc
(I_D = 6.0 mAdc, V_{GS} = 0)	MPF4392		–	–	0.4	
(I_D = 3.0 mAdc, V_{GS} = 0)	MPF4393		–	–	0.4	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MPF4391	$r_{DS(on)}$	–	–	30	Ohms
	MPF4392		–	–	60	
	MPF4393		–	–	100	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 60 mAdc, f = 1.0 kHz)	MPF4391	Y_{fs}	–	20	–	mmhos
(V_{DS} = 15 Vdc, I_D = 25 mAdc, f = 1.0 kHz)	MPF4392		–	17	–	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 1.0 kHz)	MPF4393		–	12	–	
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MPF4391	$r_{ds(on)}$	–	–	30	Ohms
	MPF4392		–	–	60	
	MPF4393		–	–	100	
Input Capacitance (V_{GS} = 15 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{iss}	–	6.0	10	pF
Reverse Transfer Capacitance (V_{GS} = 12 Vdc, V_{DS} = 0, f = 1.0 MHz)		C_{rss}	–	2.5	3.5	pF
(V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)			–	3.2	–	
SWITCHING CHARACTERISTICS (See Figure 5, R_K = 0)						
Turn-On Time (See Figures 1 and 2) ($I_{D(on)}$ = 12 mAdc)	MPF4391	t_{on}	–	3.0	15	ns
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		–	4.0	15	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		–	6.5	15	
Rise Time (See Figure 2) ($I_{D(on)}$ = 12 mAdc)	MPF4391	t_r	–	1.2	5.0	ns
($I_{D(on)}$ = 6.0 mAdc)	MPF4392		–	2.0	5.0	
($I_{D(on)}$ = 3.0 mAdc)	MPF4393		–	2.5	5.0	
Turn-Off Time (See Figures 3 and 4) ($V_{GS(off)}$ = 12 Vdc)	MPF4391	t_{off}	–	10	20	ns
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		–	20	35	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		–	37	55	
Fall Time (See Figure 4) ($V_{GS(off)}$ = 12 Vdc)	MPF4391	t_f	–	7.0	15	ns
($V_{GS(off)}$ = 7.0 Vdc)	MPF4392		–	15	20	
($V_{GS(off)}$ = 5.0 Vdc)	MPF4393		–	29	35	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON DELAY TIME

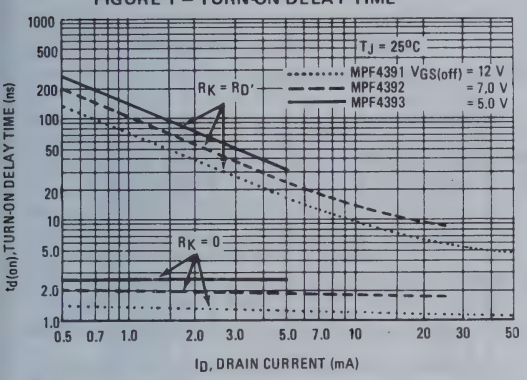


FIGURE 2 – RISE TIME

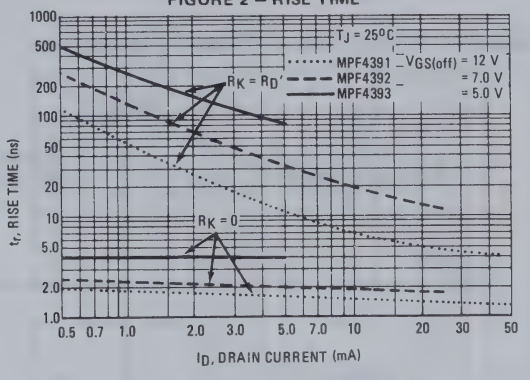


FIGURE 3 – TURN-OFF DELAY TIME

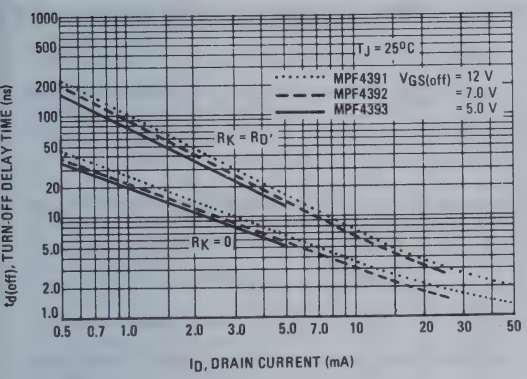


FIGURE 4 – FALL TIME

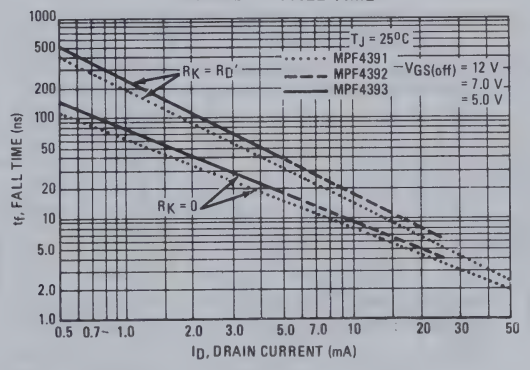
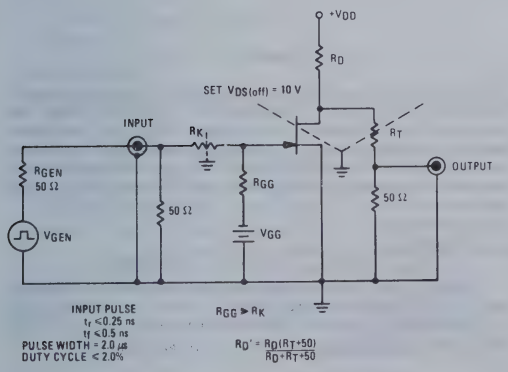


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to $R_{D'}$ which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

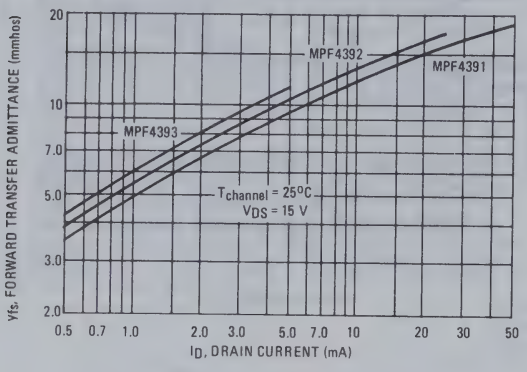


FIGURE 7 – TYPICAL CAPACITANCE

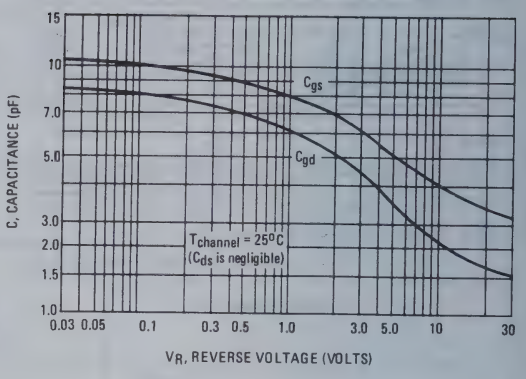


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

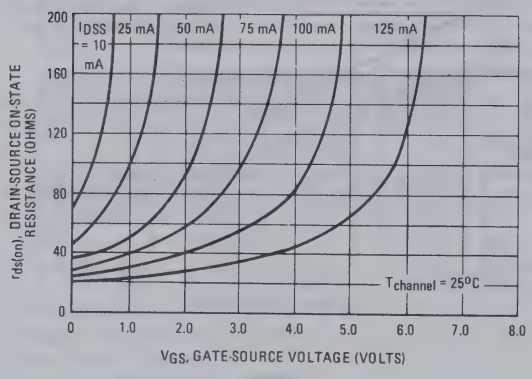


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

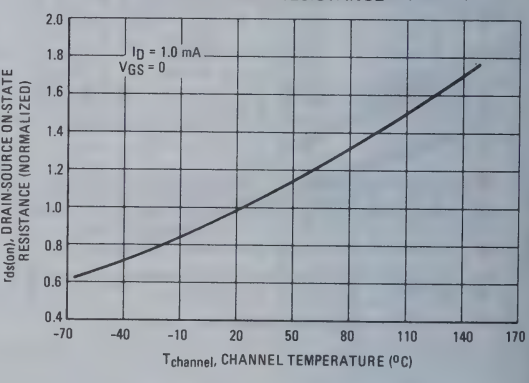
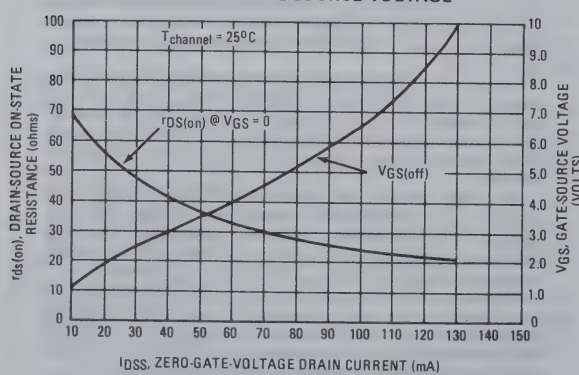


FIGURE 10 – EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

MPI-3401 (SILICON)

SILICON PIN MICRO-I DIODE

. . . designed for industrial/communications applications where space is at a premium. May be used at VHF frequencies for band switching and general-purpose attenuator circuits.

- Electrically Similar to MPN3401
- Rugged PIN Structure Coupled with Wire Bond Construction for Optimum Reliability
- Supplied in Space-Saving Miniature Package

SILICON PIN SWITCHING MICRO-I DIODE



Device marked with white top.

MAXIMUM RATINGS

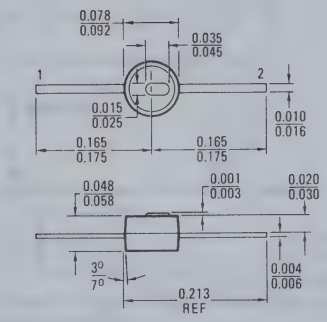
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_F	200 2.0	mW mW/^oC
Operating Junction Temperature	T_J	+125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10\ \mu A$)	$V_{(BR)R}$	35	–	–	Volts
Diode Capacitance (Note 1) ($V_R = 20$ Vdc, f = 1.0 MHz)	C_T	–	–	1.0	pF
Series Resistance (Figure 5) ($I_F = 10$ mA)	R_S	–	–	0.7	Ohms
Reverse Leakage Current ($V_R = 25$ Vdc)	I_R	–	–	0.1	μA
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop ≈ 1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.15	–	pF

NOTES

1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).



STYLE 1:
PIN 1. ANODE
2. CATHODE

CASE 166-02

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



P.C. BOARD MOUNTING

Maximum Solder Temperature 250°C for 10s

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

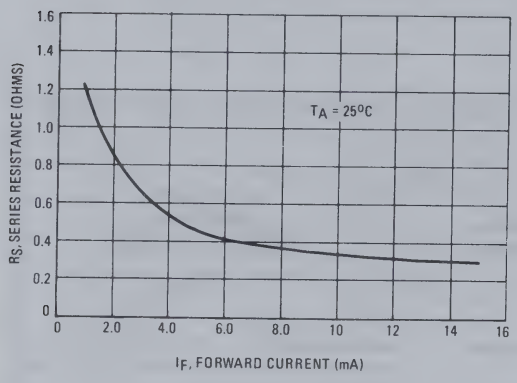


FIGURE 2 – FORWARD VOLTAGE

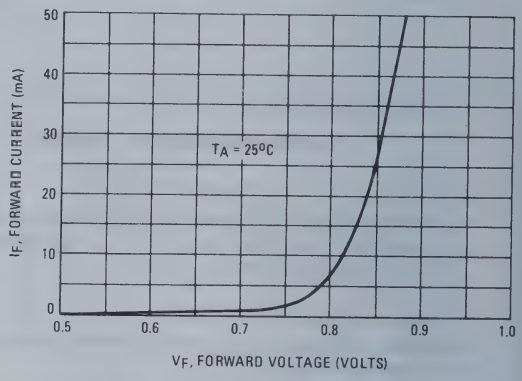


FIGURE 3 – DIODE CAPACITANCE

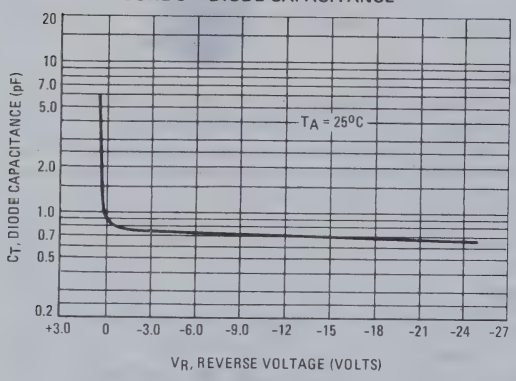


FIGURE 4 – LEAKAGE CURRENT

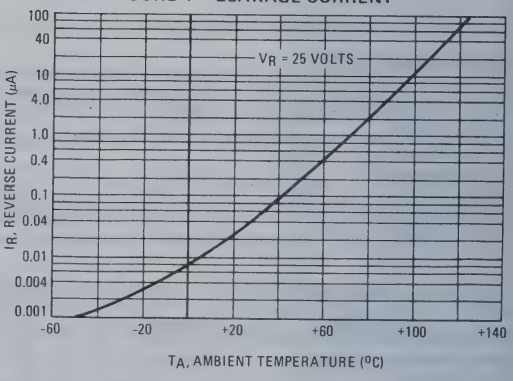
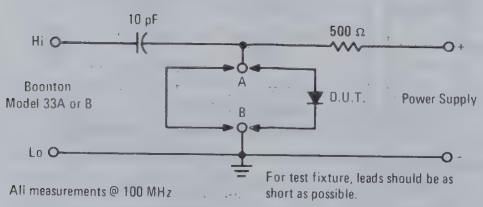


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B" Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

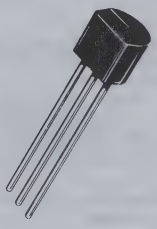
MPM5006 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for television, AM/FM, and general-purpose RF amplifier applications.

- Low Capacitance – C_{ob} = 1.6 pF (Max) @ V_{CB} = 10 Vdc
- High Power Gain – PG = 20 dB (Min) @ f = 100 MHz
- High Collector-Emitter Sustaining Voltage – $BV_{CEO(sus)}$ = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Noise Figure – NF = 5.5 dB (Typ) @ f = 100 MHz
- Forward AGC Characteristic

NPN SILICON RF AMPLIFIER TRANSISTOR

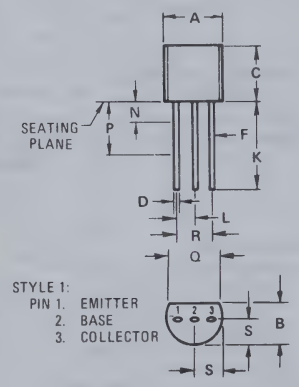


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Total Device Dissipation @T_A = 60°C Derate above 60°C	P_D	210 1.91	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	°C/mW



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPM5006 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	1.0	50	nAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 65°C)		-	-	5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	70	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	-	-	2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	-	0.98	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	1.1	1.6	pF
Small-Signal Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	6.0	-	-
Noise Figure (See Figure 2) (I_C = 4.0 mAdc, V_{CC} = 15 Vdc, R_S = 100 ohms, f = 100 MHz)	NF	-	5.5	-	dB
FUNCTIONAL TESTS					
Power Gain (I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 455 kHz)	PG	35	-	-	dB
(I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 10.7 MHz) (Figure 1)		28	-	-	
(I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 100 MHz) (Figure 2)		20	26	-	
Automatic Gain Control (I_C for which PG_{AGC} = PG -30 dB) (Figure 2)	AGC	6.0	9.0	12	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 – 10.7 MHz UNNEUTRALIZED AMPLIFIER TEST CIRCUIT

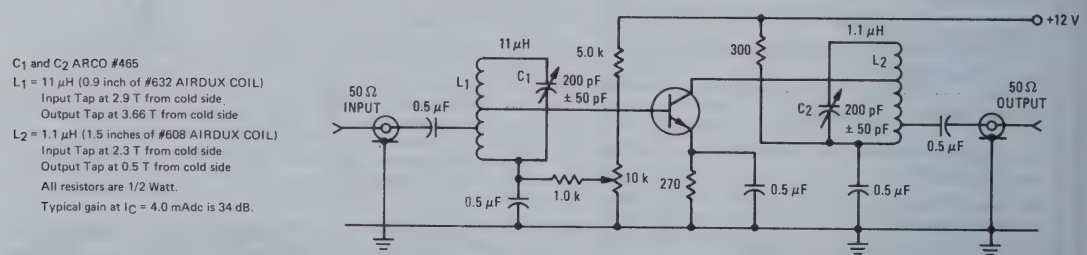
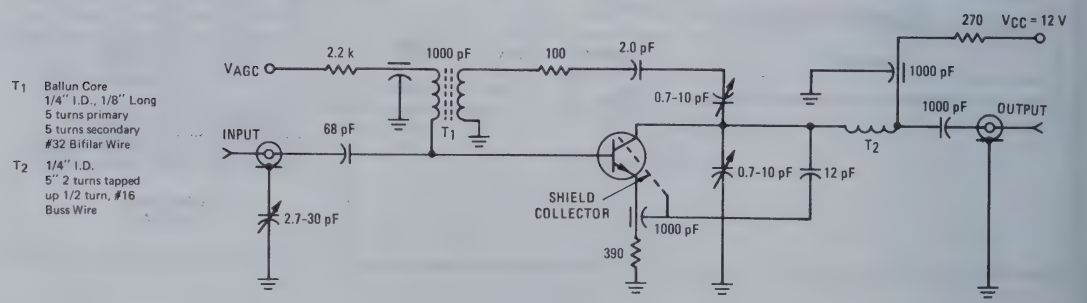


FIGURE 2 – 100 MHz AGC, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



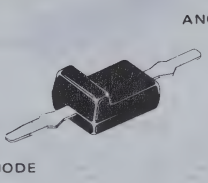
MPN3401 (SILICON)
MPN3402

SILICON PIN DIODE

. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching and attenuator circuits. Supplied in an inexpensive low-inductance plastic package for low cost, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Both 1 pF and 2 pF Devices for Design Selectivity
- Very Low Series Resistance at 100 MHz — 0.34 Ohms Typical @ I_F = 10 mAdc
- Low Inductance Mini-L Package
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

SILICON PIN SWITCHING DIODE



MPN3401 - Blue Plastic with Brown Color Stripe
MPN3402 - Blue Plastic with Red Color Stripe

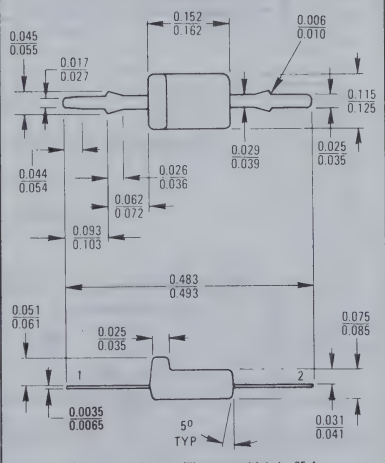
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	–	–	Volts
Diode Capacitance (Note 1) MPN3401 (V_R = 20 Vdc, f = 1.0 MHz) MPN3402	C_T	– –	– –	1.0 2.0	pF
Series Resistance (Figure 5) MPN3401 (I_F = 10 mA) MPN3402	R_S	– –	– –	0.7 0.6	Ohms
Reverse Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μA
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop ≈ 1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

NOTES
1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).



To convert inches to millimeters multiply by 25.4

Pin 1. Cathode
2. Anode

CASE 226

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

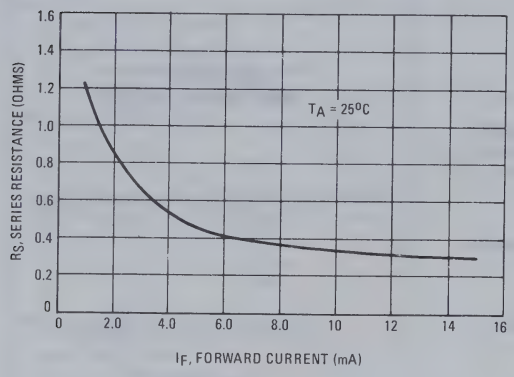


FIGURE 2 – FORWARD VOLTAGE

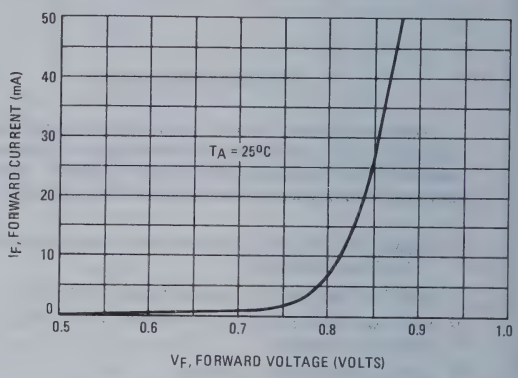


FIGURE 3 – DIODE CAPACITANCE

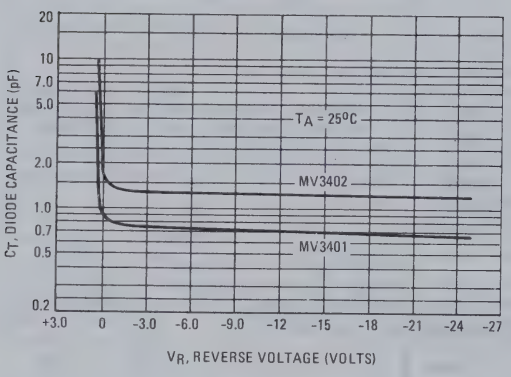


FIGURE 4 – LEAKAGE CURRENT

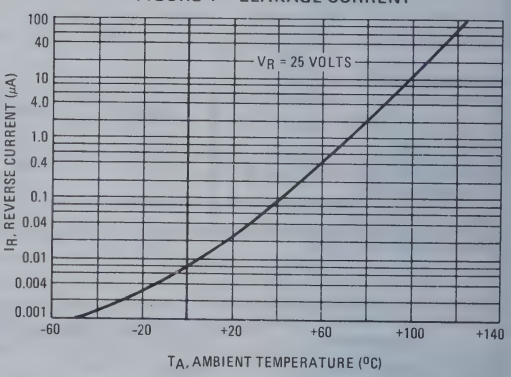
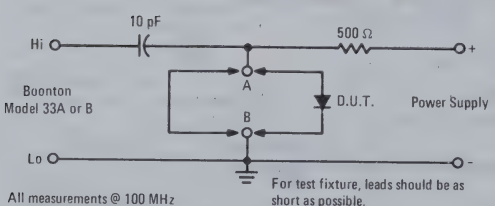


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

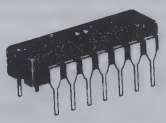
MPQ918 (SILICON)

QUAD DUAL IN-LINE NPN SILICON ANNULAR HIGH FREQUENCY AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure – @ I_C = 1.0 mAdc
  NF = 4.0 dB (Typ)
- High Current-Gain–Bandwidth Product –
  f_T = 850 MHz (Typ) @ I_C = 4.0 mAdc
- Transistors Similar to 2N918
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL IN-LINE NPN SILICON HIGH FREQUENCY AMPLIFIER TRANSISTORS



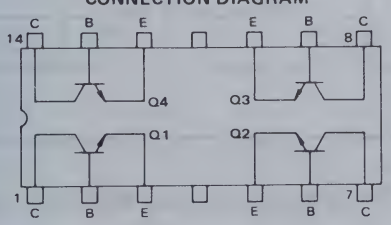
MAXIMUM RATINGS

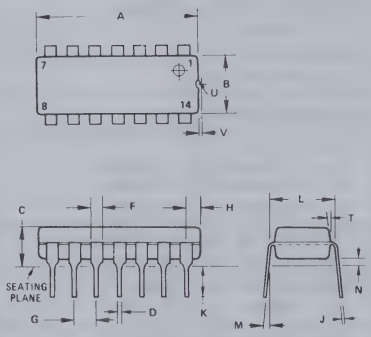
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	625 5.0	1200 9.6	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		θ_{JC} Junction to Case	θ_{JA} Junction to Ambient	Unit
Thermal Resistance	Each Die	125	200	°C/W
	Effective, 4 Die	41.6	104	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	710	740
B	6.09	6.60	240	260
C	4.06	4.57	160	180
D	38	51	015	020
F	1.02	1.65	040	065
G	2.54 BSC		100 BSC	
H	1.32	1.83	052	072
J	23	36	009	014
K	2.92	3.43	115	135
L	7.37	7.87	290	310
M	–	10°	–	10°
N	64	89	025	035
T	7° TYP		7° TYP	
U	64 RAD		025 RAD	
V	13	38	005	015

Dimension "L" to lead centerline when formed parallel

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 – 20 –	 110 80 50	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.84	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	0.75	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	1.1	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	–	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ2221, MPQ2222

For Specifications, See MHQ2221 Data.

MPQ2369

For Specifications, See MHQ2369 Data.

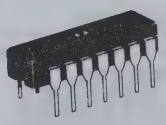
MPQ2483 (SILICON)
MPQ2484

QUAD DUAL IN-LINE NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure – @ I_C = 10 μAdc
  NF = 3.0 dB (Typ) – MPQ2483
  = 2.0 dB (Typ) – MPQ2484
- Transistors Similar to 2N2483 and 2N2484
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL IN-LINE NPN SILICON AMPLIFIER TRANSISTORS



MAXIMUM RATINGS

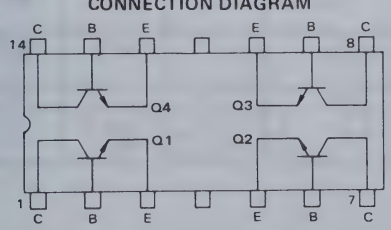
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	625 5.0	1200 9.6	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

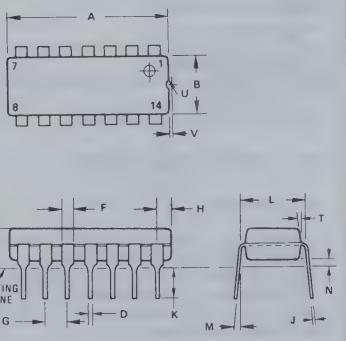
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		θJC Junction to Case	θJA Junction to Ambient	Unit
Thermal Resistance	Each Die	125	200	°C/W
	Effective, 4 Die	41.6	104	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	115	135
L	7.37	7.87	.290	.310
M	–	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		100	–	–	
	MPQ2484		200	–	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	–	–	
	MPQ2484		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483		150	–	–	
	MPQ2484		300	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	0.13	0.35	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.15	0.5	
Base-Emitter On Voltage (1)		$V_{BE(on)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			–	0.58	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			–	0.70	0.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	–	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	1.8	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	4.0	8.0	pF
Noise Figure		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MPQ2483		–	3.0	–	
	MPQ2484		–	2.0	–	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPQ2906, MPQ2907

For Specifications, See MHQ2906 Data.

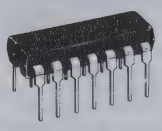
MPQ3303 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for high-speed, high-current switching and driver applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 400 MHz (Min) @ I_C = 100 mAdc
- Fast Switching Speeds at High Currents –
  t_{on} = 15 ns (Max) @ I_C = 1.0 Adc
  t_{off} = 20 ns (Max) @ I_C = 1.0 Adc

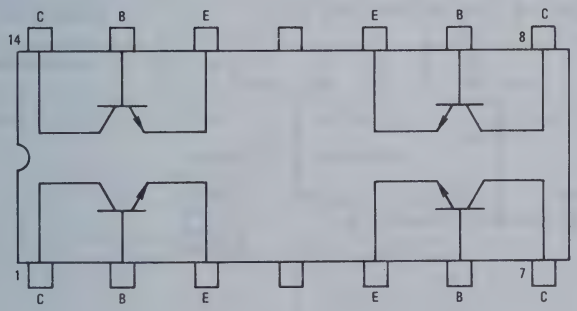
NPN SILICON QUAD CORE DRIVER TRANSISTOR

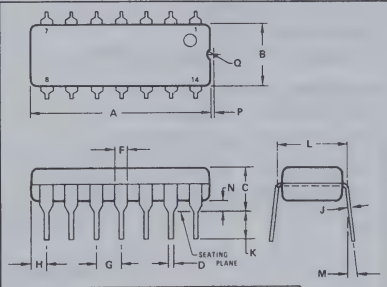


MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

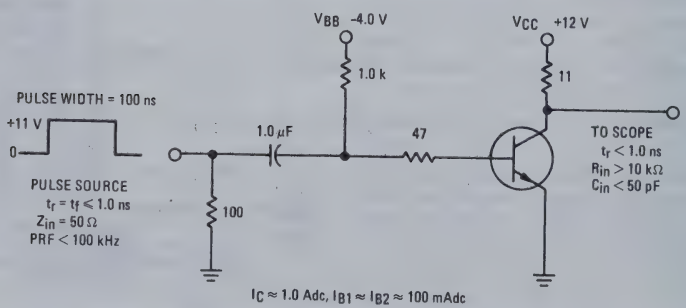
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

CASE 646

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 300 mAdc, V_{CE} = 0.5 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 30	 200 –	–
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	 – –	 0.33 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	 – –	 1.1 1.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_{on}	–	15	ns
Turn-Off Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	–	25	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



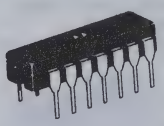
MPQ3467 (SILICON)

QUAD DUAL IN-LINE PNP SILICON ANNULAR MEMORY DRIVER TRANSISTORS

. . . designed for medium-current, high-speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc
- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching @ I_C = 500 mAdc
  t_{on} = 40 ns (Max)
  t_{off} = 90 ns (Max)
- Transistor Similar to 2N3467
- TO-116 Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON MEMORY DRIVER TRANSISTORS



MAXIMUM RATINGS

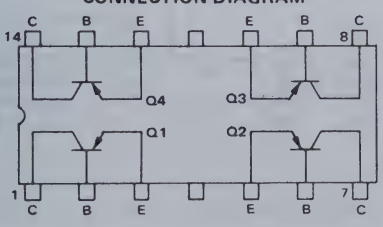
Rating	Symbol	Value		Unit
Common-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	650 5.2	1500 12	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150		°C

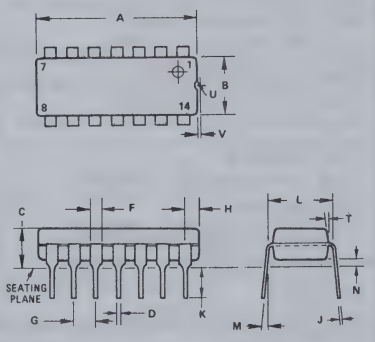
(1) Second Breakdown occurs at power levels greater than 2 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		θ_{JC} Junction to Case	θ_{JA} Junction to Ambient	Unit
Thermal Resistance	Each Die	100	193	°C/W
	Effective, 4 Die	39	83.2	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	45	55	%
	Q1-Q2 or Q3-Q4	5.0	10	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

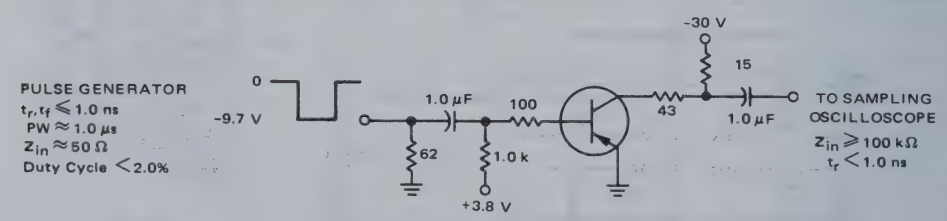
Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	0.90	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	80	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	–	40	ns
Turn-Off Time (I_C = 500 mAdc, $I_{B1} = I_{B2}$ = 50 mAdc)	t_{off}	–	–	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MPQ3546 For Specifications, See MHQ3546 Data.

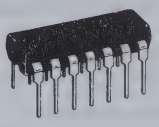
MPQ3725 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for medium-current, high-speed switching and driver applications.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching Times —
  t_{on} = 20 ns (Typ) @ I_C = 500 mAdc
  t_{off} = 50 ns (Typ) @ I_C = 500 mAdc

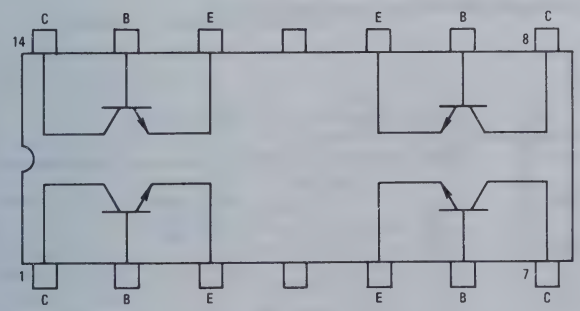
NPN SILICON QUAD CORE DRIVER TRANSISTOR

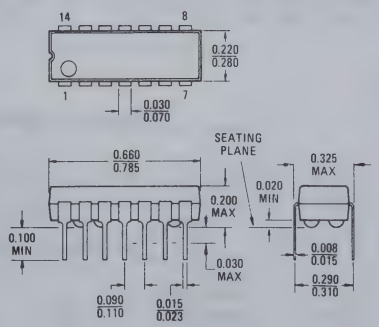


MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C

CONNECTION DIAGRAM





CASE 605-05
TO-116

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 35 25	 – –	 200 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	–	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	20	35	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	50	60	ns

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT

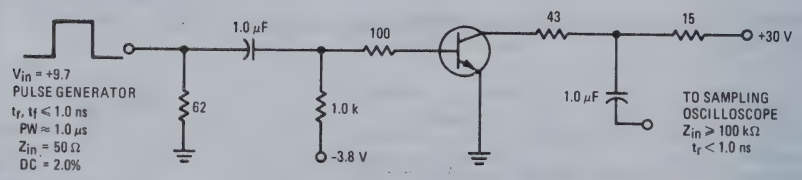


FIGURE 2 – DC CURRENT GAIN

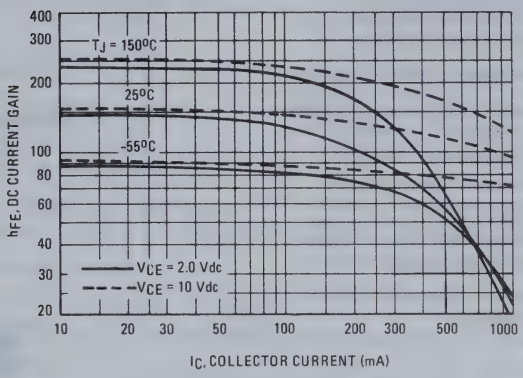


FIGURE 3 – COLLECTOR SATURATION REGION

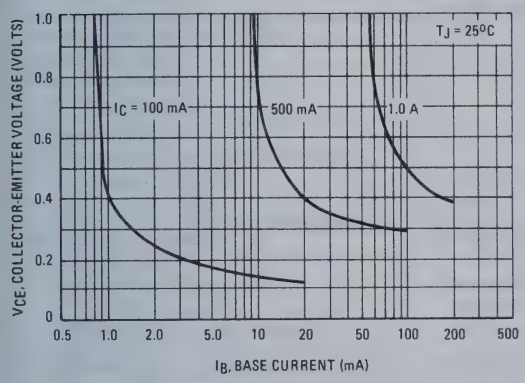


FIGURE 4 – "ON" VOLTAGES

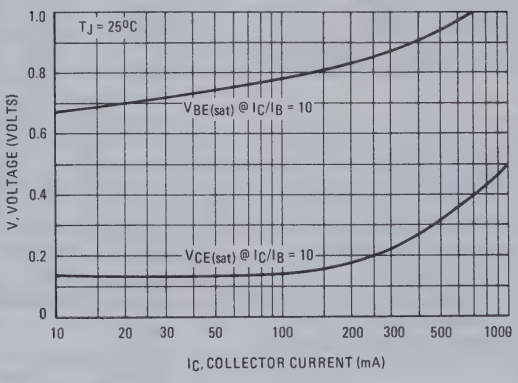


FIGURE 5 – TEMPERATURE COEFFICIENTS

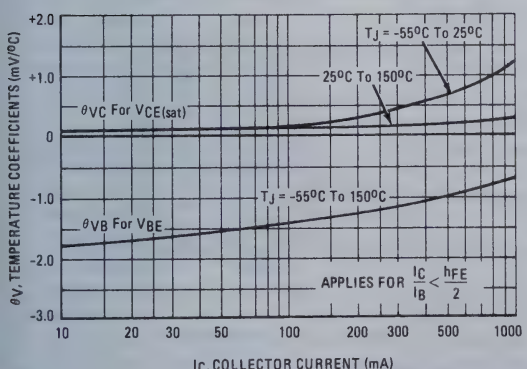
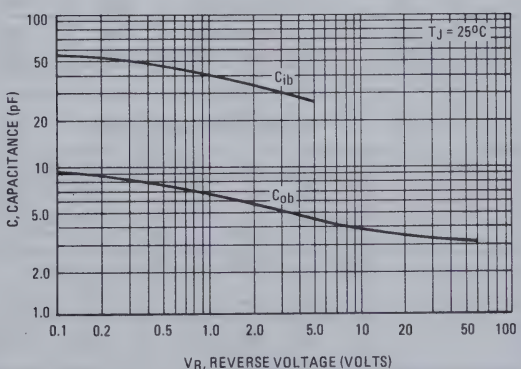


FIGURE 6 – CAPACITANCE



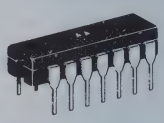
MPQ3798 (SILICON)
MPQ3799

QUAD DUAL-IN-LINE PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, low-noise amplifier applications.

- Low DC Current Gain Specified – 10 μAdc to 10 mAdc
  h_{FE} = 150 (Min) @ I_C = 500 μAdc – MPQ3798
  = 300 (Min) @ I_C = 500 μAdc – MPQ3799
- Low Capacitance –
  C_{ob} = 2.3 pF (Typ) @ V_{CB} = 5.0 Vdc
- Low Noise Figure –NF = 1.5 dB (Typ) @ I_C = 100 μAdc – MPQ3799
- Transistors Similar to 2N3798 and 2N3799
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON AMPLIFIER TRANSISTORS



MAXIMUM RATINGS

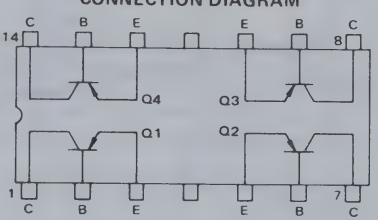
Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	625 5.0	1200 9.6	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

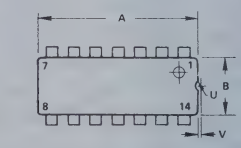
(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

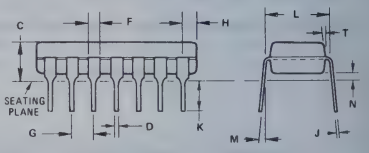
THERMAL CHARACTERISTICS

Characteristic		θ_{JC} Junction to Case	θ_{JA} Junction to Ambient	Unit
Thermal Resistance	Each Die	125	200	°C/W
	Effective, 4 Die	41.6	104	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

CONNECTION DIAGRAM







DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M		10°		10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPQ3798	BV_{CEO}	40	–	–	Vdc
	MPQ3799		60	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		100	–	–	
	MPQ3799		225	–	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	–	–	
	MPQ3799		300	–	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	–	–	
	MPQ3799		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ3798		125	–	–	
	MPQ3799		250	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			–	0.12	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	0.15	0.25	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			–	0.58	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	0.66	0.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	60	130	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.3	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	5.5	8.0	pF
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k Ohms,	MPQ3798		–	2.5	–	
f = 10 Hz to 15.7 kHz)	MPQ3799		–	1.5	–	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

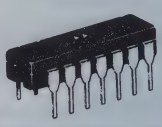
MPQ6001 (SILICON)
MPQ6002

QUAD DUAL-IN-LINE SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 1.0 to 300 mAdc
- High Current-Gain–Bandwidth Product – f_T = 400 MHz (Typ) @ I_C = 50 mAdc
- NPN Transistor Similar to 2N2218 or 2N2219
- PNP Transistor Similar to 2N2904 or 2N2905
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS



MAXIMUM RATINGS

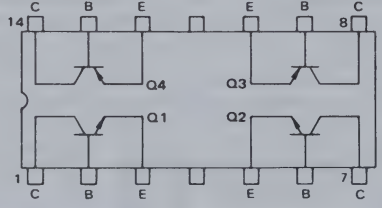
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	625 5.0	1200 9.6	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

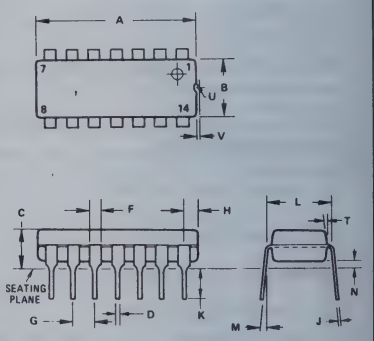
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		θ_{JC} Junction to Case	θ_{JA} Junction to Ambient	Unit
Thermal Resistance	Each Die	125	200	°C/W
	Effective, 4 Die	41.6	104	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	30	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc	MPQ6001		25	–	–	
	MPQ6002		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001		35	–	–	
	MPQ6002		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001		40	–	–	
	MPQ6002		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001		20	–	–	
	MPQ6002		30	–	–	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	–	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.4	
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	–	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	400	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	PNP	C_{ob}	–	6.0	8.0	pF
	NPN		–	4.5	8.0	
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	PNP	C_{ib}	–	20	30	pF
	NPN		–	17	30	
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)		t_{on}	–	30	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B1} = I_{B2}$ = 15 mAdc, Figure 2)		t_{off}	–	225	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≈ 2%.

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse the diodes, voltage polarities, and input pulses.

FIGURE 1 – NPN TURN-ON TIME

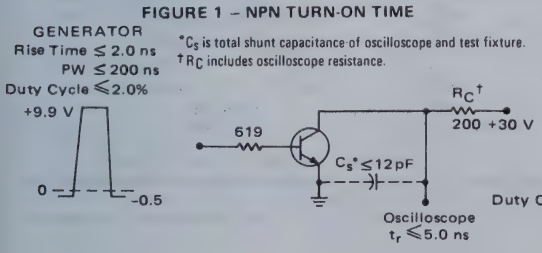
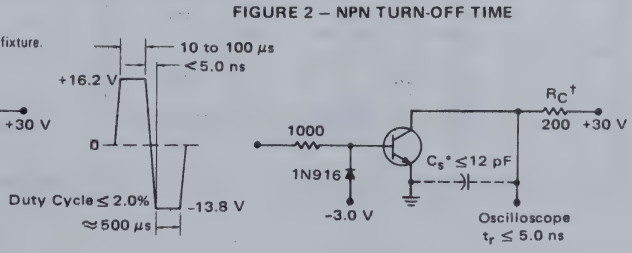


FIGURE 2 – NPN TURN-OFF TIME



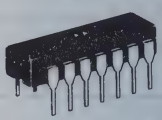
MPQ6100 (SILICON)
MPQ6100A

QUAD DUAL-IN-LINE
SILICON ANNULAR
COMPLEMENTARY PAIR TRANSISTORS

. . . designed for DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 100 μAdc to 10 mAdc
- Current-Gain–Bandwidth Product – f_T = 125 MHz (Typ) @ I_C = 0.5 mAdc
- NPN Transistor Similar to 2N2484
- PNP Transistor Similar to 2N3799
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE
SILICON
COMPLEMENTARY PAIR
TRANSISTORS



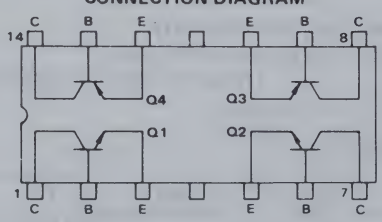
MAXIMUM RATINGS

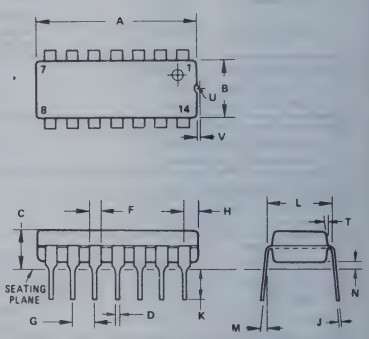
Rating	Symbol	MPQ6100	MPQ6100A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	625 5.0	1200 9.6	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		θ_{JC} Junction to Case	θ_{JA} Junction to Ambient	Unit
Thermal Resistance	Each Die	125	200	°C/W
	Effective, 4 Die	41.6	104	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	30	60	%
	Q1-Q2 or Q3-Q4	2.0	25	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	-	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\triangle T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where $\triangle T_{J1}$ is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \triangle T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\triangle T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPQ6100	BV_{CEO}	40	–	–	Vdc
	MPQ6100A		45	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100		50	95	–	
	MPQ6100A		100	200	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100		75	140	–	
	MPQ6100A		150	300	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100		75	140	–	
	MPQ6100A		150	300	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100		60	110	–	
	MPQ6100A		125	275	–	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	–	0.1	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	–	0.65	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	125	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	PNP	C_{ob}	–	1.2	4.0	pF
	NPN		–	1.8	4.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	PNP	C_{ib}	–	5.5	8.0	pF
	NPN		–	6.0	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)		NF	–	4.0	–	dB

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

MPS404 (SILICON)
MPS404A

PNP silicon annular transistors encapsulated in plastic package designed for medium-speed switching applications in industrial and computer equipment. Intended for operation in applications using the 2N404 and 2N404A transistors.



CASE 29 (1)
(TO-92)

PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — SWITCHING TEST CIRCUIT

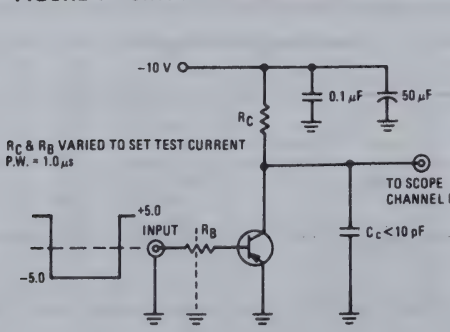
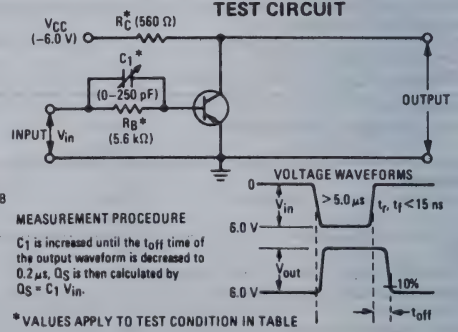


FIGURE 2 — STORED BASE CHARGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS404 MPS404A	BV_{CEO}	24 35	- -	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS404 MPS404A	BV_{CBO}	25 40	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS404 MPS404A	BV_{EBO}	12 25	- -	- -	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)		h_{FE}	30	-	400	-
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	- -	- -	0.15 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	- -	- -	0.85 1.0	Vdc
DYNAMIC CHARACTERISTICS						
Common-Base Cutoff Frequency (I_C = 1.0 mAdc, V_{CB} = 6.0 Vdc)		f_{ob}	4.0	-	-	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0)		C_{ob}	-	-	20	pF
SWITCHING CHARACTERISTICS						
Delay Time	(I_C = 10 mAdc, I_{B1} = 1.0 mAdc) (Figure 1)	t_d	-	75	-	ns
Rise Time		t_r	-	190	-	ns
Storage Time	(I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (Figure 1)	t_s	-	155	-	ns
Fall Time		t_f	-	230	-	ns
Total Control Charge (Figure 2) (I_C = 10 mAdc, I_B = 1.0 mAdc)		Q_S	-	-	1400	pC

FIGURE 3 – BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

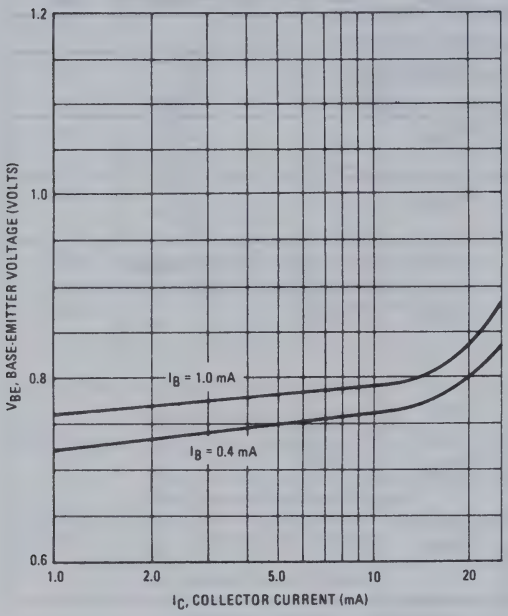


FIGURE 4 – BASE-EMITTER VOLTAGE versus TEMPERATURE

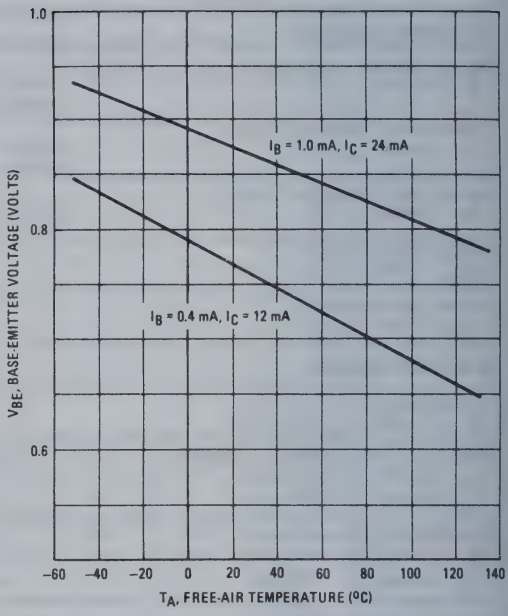


FIGURE 5 – COLLECTOR-EMITTER VOLTAGE versus COLLECTOR CURRENT

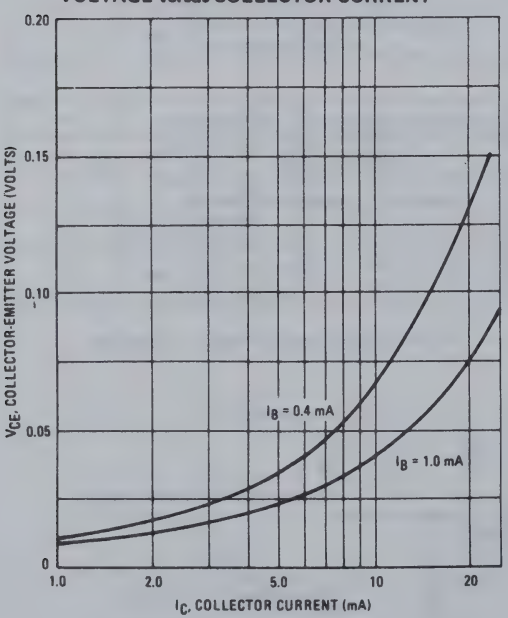


FIGURE 6 – COLLECTOR-EMITTER VOLTAGE versus TEMPERATURE

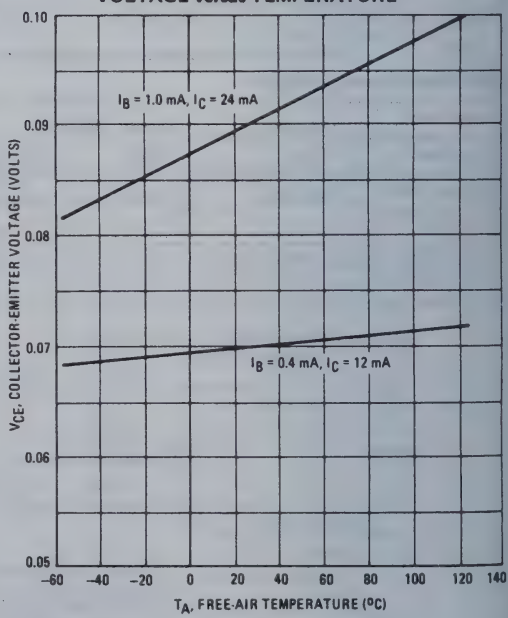


FIGURE 7 – NORMALIZED DC CURRENT GAIN

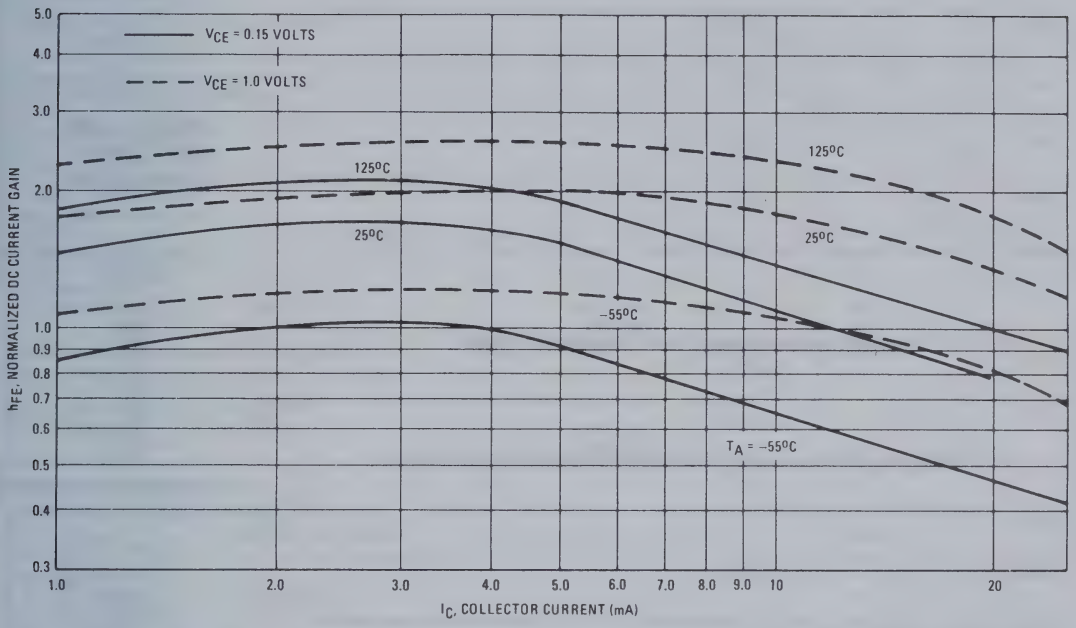


FIGURE 8 – COMMON-BASE CAPACITANCE

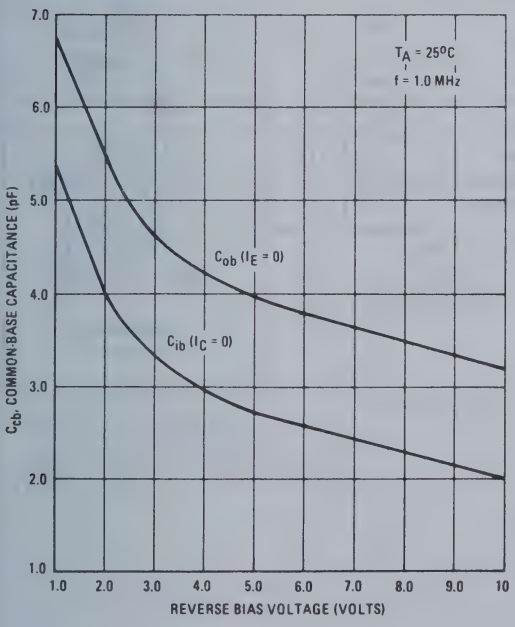
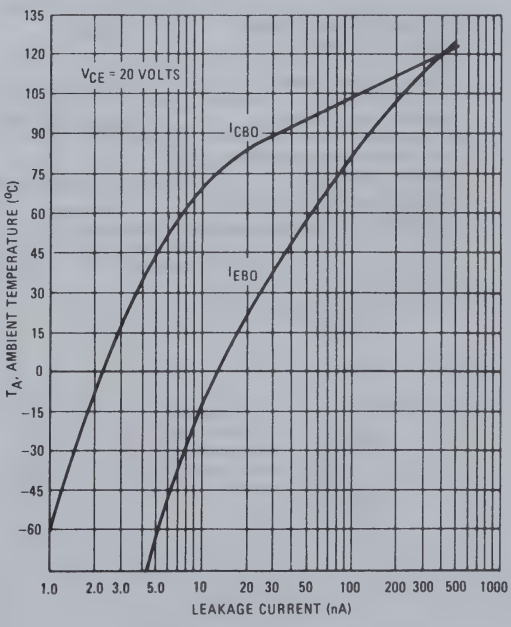
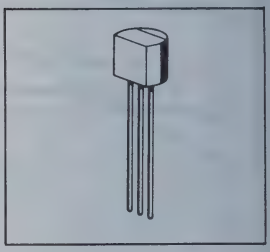


FIGURE 9 – TEMPERATURE versus LEAKAGE CURRENT



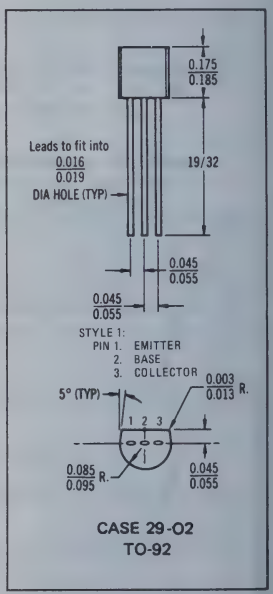
MPS706 (SILICON)
MPS706A

NPN SILICON SWITCHING TRANSISTORS



NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-level, high-speed switching applications.



CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	MPS706	MPS706A	Unit
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Total Device Dissipation@ T_A=25°C Derate above 25°C	P_D (1)	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 Ohms)		BV_{CER}	20	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	-	0.5	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
ON CHARACTERISTICS					
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MPS706 MPS706A	h_{FE}	20 20	- 60	-
Collector-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS706 MPS706A	$V_{BE(sat)}$	- 0.7	0.9 0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	200	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	6.0	pF
Base Resistance (I_E = 10 mAdc, V_{CE} = 15 Vdc, f = 300 MHz)		r'_b	-	50	Ohms
SWITCHING CHARACTERISTICS					
Turn-On Time (See Figure 1)		t_{on}**	-	40	ns
Turn-Off Time (See Figure 1)		t_{off}**	-	75	ns
Charge Storage Time Constant** (See Figure 2)	MPS706 MPS706A	τ_s**	- -	60 25	ns

*Pulse Test: Pulse Width ≤ 12 ns, Duty Cycle ≤ 2.0%.

**Measured with Tektronix Type R Plug-In (50-Ohm Internal Impedance) and circuits shown.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

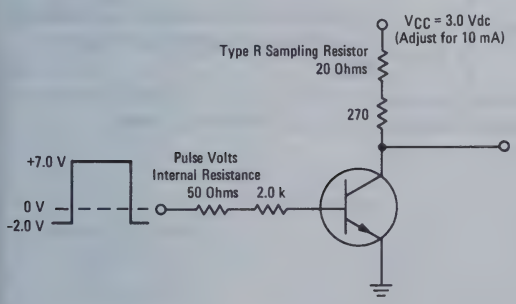
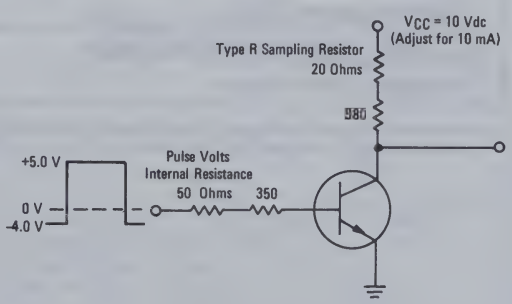


FIGURE 2 – STORAGE TIME TEST CIRCUIT



MPS834 (SILICON)



NPN silicon annular transistor designed for high-speed switching applications.

CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

CHARACTERISTICS	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	-	-
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	0.4	
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	350	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc) See Figure 1	t_{on}	-	16	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc) See Figure 1	t_{off}	-	30	ns
Storage Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc) See Figure 2	t_s	-	25	ns

(1) Pulse Test: Pulse Width ≤ 12 ns, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT

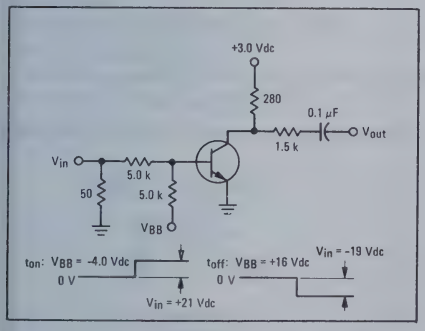
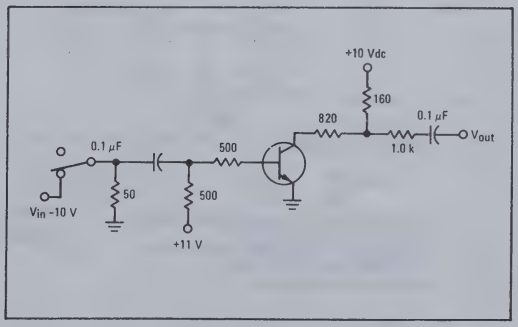


FIGURE 2 – CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

MPS918 (SILICON)
MPS3563

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF/UHF low-level amplifier, and oscillator applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 10 mAdc

NPN SILICON AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

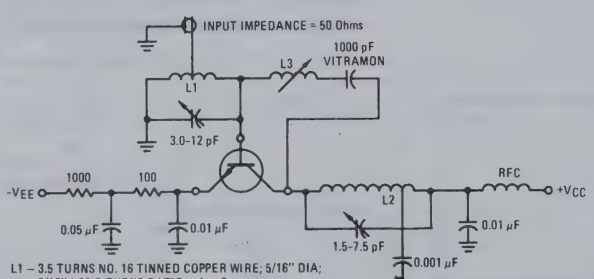
Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	2.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C



THERMAL CHARACTERISTICS

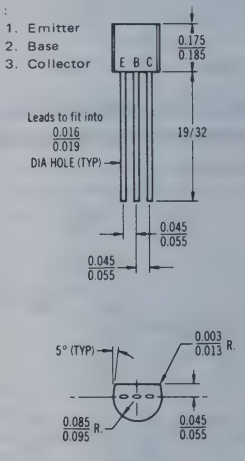
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	°C/mW

FIGURE 1 – 200 MHz POWER GAIN TEST CIRCUIT



L1 – 3.5 TURNS NO. 16 TINNED COPPER WIRE; 5/16" DIA; 7/16" LONG TURNS RATIO ≈ 4 to 2
L2 – 8 TURNS NO. 16 TINNED COPPER WIRE; 1/8" DIA; 7/8" LONG TURNS RATIO ≈ 8 TO 1
L3 – MILLER #4303 (0.4-0.65 μH)

Style 1:
Pin 1. Emitter
2. Base
3. Collector



CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 3.0 mAdc, I_B = 0)	MPS918 MPS3563	BV_{CEO}*	 15 12	 – –	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0) (I_C = 100 μAdc, I_E = 0)	 MPS918 MPS3563	BV_{CBO}	 30 30	 – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	 MPS918 MPS3563	BV_{EBO}	 3.0 2.0	 – –	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	 MPS918 MPS3563	I_{CBO}	 – –	 10 50	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	 MPS918 MPS3563	h_{FE}*	 20 20	 – 200	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	 MPS918	$V_{CE(sat)}$	 –	 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	 MPS918	$V_{BE(sat)}$	 –	 1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	 MPS918 MPS3563	f_T	 600 600	 – 1500	MHz
Output Capacitance (V_{CB} = 0 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	 MPS918 MPS918 MPS3563	C_{ob}	 – – –	 3.0 1.7 1.7	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS918	C_{ib}	–	2.0	pF
Small-Signal Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3563	h_{fe}	20	250	–
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	MPS918	NF	–	6.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) ($G_{fd} + G_{re} < -20$ dB)	 MPS918 MPS3563	G_{pe}	 15 14	 – –	dB
Power Output (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz)	MPS918	P_{out}	30	–	mW
Oscillator Collector Efficiency (I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz)	MPS918	η	25	–	%

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS2369 (SILICON)



CASE 29-02
TO-92

NPN silicon annular switching transistor designed for use in high-speed, low-current switching applications.

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current-Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to + 135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.355	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 – t_{on} CIRCUIT

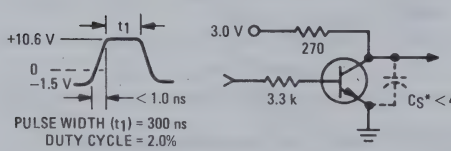


FIGURE 2 – t_{off} CIRCUIT

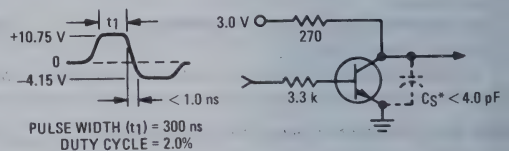
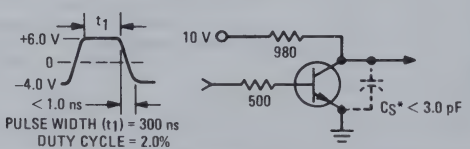


FIGURE 3 – STORAGE TEST CIRCUIT



*Total shunt capacitance of test jig and connectors.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.4	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)		-	30	
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	120	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	-	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		20	-	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	5.0	-	-
SWITCHING CHARACTERISTICS				
Turn-On Time (1) V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 1)	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Figure 2)	t_{off}	-	18	ns
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	t_s	-	13	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

MPS2711 (SILICON)
MPS2712



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon epitaxial transistor designed for low-power, small-signal audio applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous MPS2711, 12	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D (1)	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J (1)	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	$^oC/W$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25^oC$, Derate above $25^oC - 8.0$ mW/^oC, $T_J = -65$ to $+150^oC$, $\theta_{JC} = 125^o$ C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 V_{dc} I_E = 0, T_A = 100°C)		I_{CBO}	- -	0.5 1.5	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.5	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS2711 MPS2712	h_{FE}	30 75	90 225	-
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}	-	4.0	pF
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz)	MPS2711 MPS2712	h_{fe}	30 80	120 200	-

MPS2713 (SILICON)
MPS2714



NPN Silicon annular transistor, designed for general purpose low-level switching applications.

CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CE}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210	mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	310 2.81	mW mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}(1)	0.357	°C/mW
Storage Temperature Range	T_{stg}	-55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

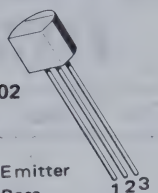
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	— —	— —	0.5 15	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc)	MPS2713	h_{FE}	30	60	90	—
	MPS2714		75	150	225	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{CE(sat)}$	—	0.16	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{BE(sat)}$	0.6	0.75	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS						
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc, f = 1 kHz)	MPS2713	h_{fe}	30	—	120	—
	MPS2714		80	—	300	
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	—	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	2.5	—	pF
Input Impedance (I_C = 0.5 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)		h_{ie}	—	3000	—	ohms
SWITCHING CHARACTERISTICS						
Delay Time	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 10 V	t_d	—	7.0	—	ns
Rise Time		t_r	—	6.0	—	ns
Storage Time	I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1 mA, V_{CC} = 10 V	t_s	—	12	—	ns
Fall Time		t_f	—	9.0	—	ns

MPS2923 thru MPS2925 (SILICON)



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon annular transistors for low-cost, medium-speed, general-purpose amplifier and oscillator applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor above 25°C	P_D (1)	200 2.67	mW mW/°C
Total Device Dissipation @ 55°C Case Temperature Derating Factor above 25°C	P_D	120 2.67	mW mW/°C
Junction Temperature-Operating	T_J (1)	100	°C
Storage Temperature Range	T_{stg}	-30 to +125	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 25 V, I_E = 0 V_{CB} = 25 V, I_E = 0, T_A = 100°C	I_{CBO}	– –	0.5 15	μA μA
Emitter Cutoff Current V_{EB} = 5 V	I_{EBO}	–	0.5	μA
Small Signal Current Gain (f = 1 kHz) V_{CE} = 10 V, I_C = 2 mA MPS2923 MPS2924 MPS2925	h_{fe}	 90 150 235	 180 300 470	–
Collector Capacitance V_{CB} = 10 V, I_E = 0, f = 1 MHz	C_{ob}	–	12	pF

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

MPS2926 (SILICON)
MPS3721



CASE 29-02
TO-92

NPN silicon epitaxial transistors designed for general-purpose applications.

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature	P_D (1)	310	mW
Total Device Dissipation @ 60°C Case Temperature	P_D	210	mW
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	°C/mW
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	μA
(V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)		—	—	15	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μA
Current Gain — Bandwidth Product (I_C = 4 mA, V_{CE} = 5 V) MPS2926	f_T	—	300	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	—	—	3.5	pF
Small Signal Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}				—
MPS2926		35	—	470	
MPS3721		60	—	660	

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

Each unit will be branded with the MPS2926 type and also by color code to identify the different A-C beta categories. A-C beta is broken down into five groups, and typical values of DC beta are listed for guidance.

MPS2926 Color Code	h_{fe} (V_{CE} = 10 V, I_C = 2 mA, f = 1 KHz)		h_{FE} (V_{CE} = 4.5 V, I_C = 2 mA)
	Min	Max	Typ
Brown	35	70	36
Red	55	110	62
Orange	90	180	115
Yellow	150	300	155
Green	235	470	215

MPS3392 thru MPS3395 (SILICON)



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon annular transistors designed for small-signal, low power audio applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D (1)	210	mW
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ $T_C = 25^oC$, Derate above 25^oC — 8.0 mW/^oC, T_J = -65 to +150^oC, $\theta_{JC} = 125^oC/W$.

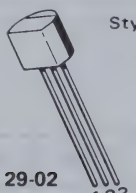
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	25	-	Vdc
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)		I_{CBO}	-	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.1	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS3392 MPS3393 MPS3394 MPS3395	h_{FE}	150 90 55 150	300 180 110 500	-
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}	-	3.5	pF
Small Signal Current Gain (V_{CE} = 4.5 V, I_C = 2 mA, f = 1 kHz)	MPS3392 MPS3393 MPS3394 MPS3395	h_{fe}	150 90 55 150	500 400 300 800	-

MPS3563

For Specifications, See MPS918 Data.

MPS3638 (SILICON)
MPS3638A



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

PNP silicon epitaxial transistor designed for high-current digital applications.

MAXIMUM RATINGS

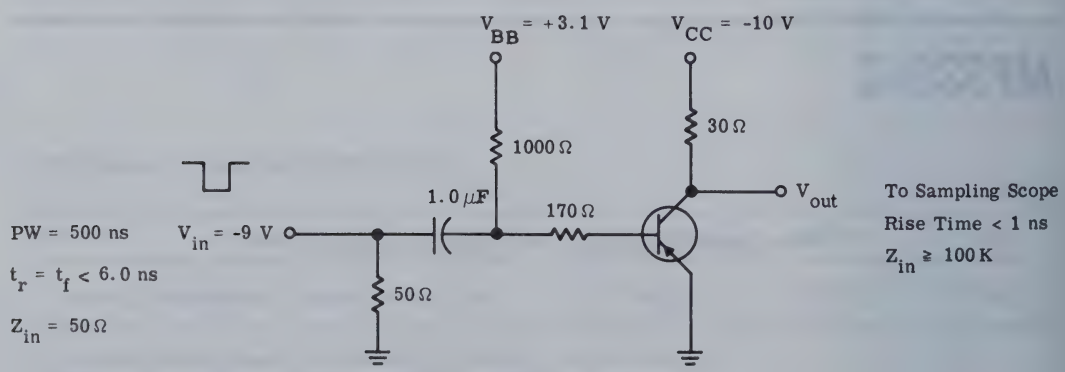
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

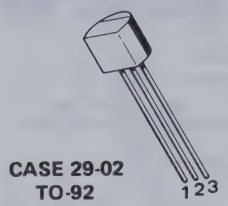
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	25	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Reverse Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	-	0.035	μAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +65°C)			-	2.0	
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_B	-	0.035	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			-
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MPS3638A		80	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS3638		20	-	
	MPS3638A		100	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	MPS3638		30	-	
	MPS3638A		100	-	
(I_C = 300 mAdc, V_{CE} = 2 Vdc)	MPS3638		20	-	
	MPS3638A		20	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)			-	0.25	
(I_C = 300 mAdc, I_B = 30 mAdc)			-	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)			-	1.1	
(I_C = 300 mAdc, I_B = 30 mAdc)			0.80	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 3 Vdc, I_C = 50 mAdc, f = 100 MHz)	MPS3638	f_T	100	-	MHz
	MPS3638A		150	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	MPS3638	C_{ob}	-	20	pF
	MPS3638A		-	10	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS3638	C_{ib}	-	65	pF
	MPS3638A		-	25	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{fe}	25	180	-
	MPS3638A		100	-	
Output Conductance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	1.2	mmhos
Input Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{ie}	-	1500	Ohms
	MPS3638A		-	2000	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{re}	-	26	$X10^{-4}$
	MPS3638A		-	15	

SWITCHING CHARACTERISTICS

Delay Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_d	-	20	ns
Rise Time	I_{B1} = 30 mAdc, $V_{BE(off)}$ = 3.1 Vdc	t_r	-	70	ns
Storage Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_s	-	140	ns
Fall Time	I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_f	-	70	ns
Turn-On Time	I_C = 300 mAdc, I_{B1} = 30 mAdc	t_{on}	-	75	ns
Turn-Off Time	I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_{off}	-	170	ns

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1%.

MPS3639 (SILICON)



CASE 29-02
TO-92

PNP silicon annular transistor for low-cost, low-level, high-speed switching applications.

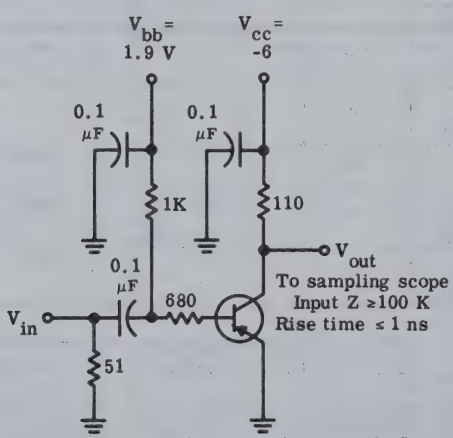
Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	6.0	Vdc
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	80	mAdc
Total Device Dissipation @ 25° Ambient Temperature	P_D	0.2	Watts
Derate above 25° C		2.0	mW/°C
Total Device Dissipation @ 25° C Case Temperature	P_D (1)	0.5	Watts
Derate above 25° C		5.0	mW/°C
Operating Junction Temperature	T_J (1)	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

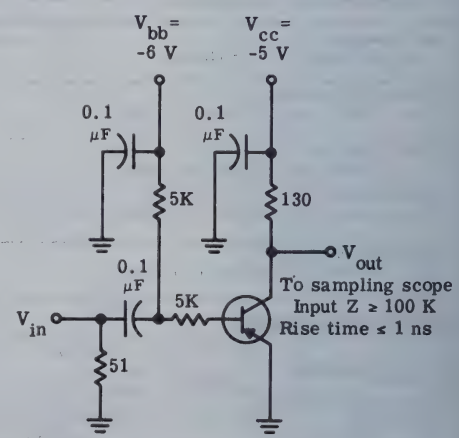
(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

SWITCHING TIME TEST CIRCUITS



PULSE SOURCE
Rise time ≤ 1 ns
PW ≥100 ns
Z_{in} = 50Ω
Fall time ≤1 ns

NOTES: (1) Collector Current = 50 mA
(2) Turn-On and Turn-Off Base Currents = 5 mA



PULSE SOURCE
Rise time ≤ 1 ns
PW ≥ 200 ns
Z_{in} = 50Ω
Fall time ≤1 s

NOTES: (1) Collector Current = 10 mA
(2) Turn-On and Turn-Off Base Currents = 0.5 mA

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current	I_{CES}			μA
V_{CE} = 3 V, V_{EB} = 0		–	0.01	
V_{CE} = 3 V, V_{EB} = 0, T_A = +65°C		–	1.0	
Base Current V_{CE} = 3 V, V_{EB} = 0	I_B	–	10	nA
Collector-Emitter Breakdown Voltage I_C = 100 μA, V_{BE} = 0	BV_{CES}	6.0	–	V
Collector-Base Breakdown Voltage I_C = 100 μA, I_E = 0	BV_{CBO}	6.0	–	V
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BV_{EBO}	4.0	–	V
Collector-Emitter Sustaining Voltage [1] I_B = 0, I_C = 10 mA	$V_{CEO(sus)}$	6.0	–	V
Collector-Emitter Saturation Voltage [1]	$V_{CE(sat)}$			V
I_C = 10 mA, I_B = 1 mA		–	0.16	
I_C = 50 mA, I_B = 5 mA		–	0.5	
I_C = 10 mA, I_B = 1 mA, T_A = +65°C		–	0.23	
Base-Emitter Saturation Voltage [1]	$V_{BE(sat)}$			V
I_C = 10 mA, I_B = 0.5 mA		0.75	0.95	
I_C = 10 mA, I_B = 1 mA		0.8	1.0	
I_C = 50 mA, I_B = 5 mA		–	1.5	
Forward Current Transfer Ratio [1]	h_{FE}			–
V_{CE} = 0.3 V, I_C = 10 mA		30	120	
V_{CE} = 1.0 V, I_C = 50 mA		20	–	

[1] Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Small-Signal Current Transfer Ratio V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz V_{CB} = 0, I_C = 10 mA, f = 100 MHz	h_{fe}	 5.0 3.0	 – –	–
Output Capacitance I_E = 0, V_{CB} = 5 V, f = 140 kHz	C_{ob}	–	3.5	pF
Input Capacitance V_{BE} = 0.5 V, I_C = 0, f = 140 kHz	C_{ib}	–	3.5	pF
Delay Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA $V_{BE(off)}$ = 1.9 V	t_d	–	10	ns
Rise Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, $V_{BE(off)}$ = 1.9 V	t_r	–	30	ns
Storage Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_s	–	20	ns
Fall Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_f	–	12	ns
Turn-On Time I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V I_C = 10 mA, I_{B1} = 0.5 mA	t_{on}	 – –	 25 60	ns
Turn-Off Time I_C = 50 mA, V_{OB} = 1.9 V, I_{B1} = I_{B2} = 5 mA I_C = 10 mA, I_{B1} = I_{B2} = 0.5 mA	t_{off}	 – –	 25 60	ns

MPS3640 (SILICON)



CASE 29-02
TO-92

PNP silicon annular transistors designed for general-purpose low-level switching applications.

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	80	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

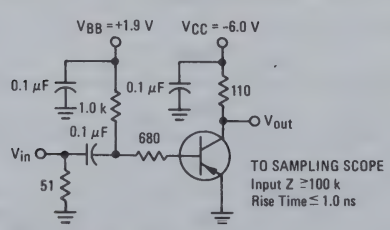
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	- -	0.01 1.0	μAdc

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) **(continued)**

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 30 20	 120 -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (1) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)		$V_{CE(sat)}$	 - - -	 0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)*		$V_{BE(sat)}$	 0.75 0.8 -	 0.95 1.0 1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	500	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	-	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{BE(off)}$ = 1.9 Vdc, V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc) (See Figure 1) (I_C = 10 mAdc, V_{CC} = 1.5 Vdc, I_{B1} = 0.5 mAdc) (See Figure 2)		t_{on}	 - -	 25 60	ns
Delay Time	(V_{CC} = 6.0 Vdc, $V_{BE(off)}$ = 1.9 Vdc,	t_d	-	10	ns
Rise Time	I_C = 50 mAdc, I_{B1} = 5.0 mAdc) (See Figure 1)	t_r	-	30	ns
Turn-Off Time ($V_{BE(off)}$ = 1.9 Vdc, V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc) (See Figure 1) (I_C = 10 mAdc, V_{CC} = 1.5 Vdc, I_{B1} = I_{B2} = 0.5 mAdc) (See Figure 2)		t_{off}	 - -	 35 75	ns
Storage Time	(V_{CC} = 6.0 Vdc, I_C = 50 mAdc,	t_s	-	20	ns
Fall Time	I_{B1} = I_{B2} = 5.0 mAdc) (See Figure 1)	t_f	-	12	ns

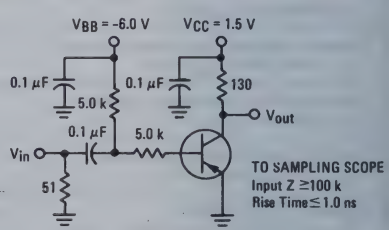
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time
Base Currents = 5.0 mA.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time
Base Currents = 0.5 mA.

MPS3646 (SILICON)



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon annular transistor designed for high-speed saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage Applicable 0.01-200 mA	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	200	mA
Collector Current (10 μs pulse)	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	200 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 5.0	mW mW/°C
Operating Junction Temperature	T_J (1)	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — t_{on} and t_{off} TEST CIRCUIT

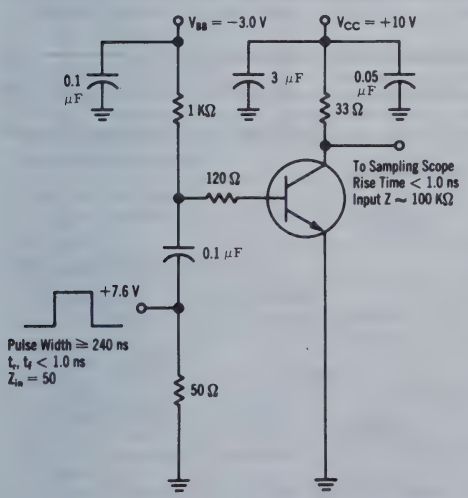
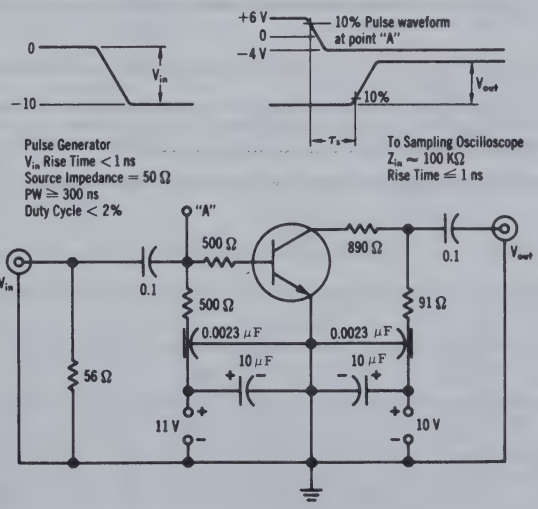


FIGURE 2 — CHARGE STORAGE TIME MEASUREMENT CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage	I_C = 100 μAdc, I_E = 0	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage	I_C = 100 μAdc, V_{BE} = 0	BV_{CES}	40	—	Vdc
Collector-Emitter Sustaining Voltage (1)	I_C = 10 mAdc	$V_{CEO(sus)}$	15	—	Vdc
Emitter-Base Breakdown Voltage	I_E = 100 μAdc, I_C = 0	BV_{EBO}	5.0	—	Vdc
Collector-Emitter Saturation Voltage (1)	I_C = 30 mAdc, I_B = 3.0 mAdc	$V_{CE(sat)}$	—	0.2	Vdc
	I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +65 C		—	0.3	
	I_C = 100 mAdc, I_B = 10 mAdc		—	0.28	
	I_C = 300 mAdc, I_B = 30 mAdc		—	0.5	
Base-Emitter Saturation Voltage (1)	I_C = 30 mAdc, I_B = 3.0 mAdc	$V_{BE(sat)}$	0.75	0.95	Vdc
	I_C = 100 mAdc, I_B = 10 mAdc		—	1.2	
	I_C = 300 mAdc, I_B = 30 mAdc		—	1.7	
DC Current Gain (1)	I_C = 30 mAdc, V_{CE} = 0.4 Vdc	h_{FE}	30	120	—
	I_C = 100 mAdc, V_{CE} = 0.5 Vdc		25	—	
	I_C = 300 mAdc, V_{CE} = 1.0 Vdc		15	—	
Collector Reverse Current	V_{CE} = 20 Vdc, V_{EB} = 0	I_{CES}	—	0.5	μAdc
	V_{CE} = 20 Vdc, V_{EB} = 0, T_A = +65 C		—	3.0	
Base Current	V_{CE} = 20 Vdc, V_{EB} = 0	I_B	—	0.5	μAdc
Output Capacitance	V_{CB} = 5.0 V, I_E = 0, f = 140 kHz	C_{ob}	—	5.0	pF
Input Capacitance	V_{BE} = 0.5 V, I_C = 0, f = 140 kHz	C_{ib}	—	9.0	pF
Small-Signal Current Gain	I_C = 30 mA, V_{CE} = 10 V, f = 100 MHz	h_{fe}	3.5	—	—
Turn-On Delay Time (Figure 1)	V_{CC} = +10 V, I_{CS} = 300 mA, I_{B1} = 30 mA, $V_{BE(off)}$ = -3.0 V	t_d	—	10	ns
Rise Time (Figure 1)	V_{CC} = +10 V, I_{CS} = 300 mA, I_{B1} = 30 mA, $V_{BE(off)}$ = -3.0 V	t_r	—	15	ns
Turn-On Time (Figure 1)	I_C = 300 mA, I_{B1} = 30 mA, $V_{BE(off)}$ = -3.0 V	t_{on}	—	18	ns
Storage Time (Figure 1)	V_{CC} = +10 V, I_{CS} = 300 mA, I_{B1} = 30 mA, I_{B2} = -30 mA	t_s	—	20	ns
Fall Time (Figure 1)	V_{CC} = +10 V, I_{CS} = 300 mA, I_{B1} = 30 mA, I_{B2} = -30 mA	t_f	—	15	ns
Turn-Off Time (Figure 1)	I_C = 300 mA, I_{B1} = 30 mA, I_{B2} = -30 mA	t_{off}	—	28	ns
Charge Storage Time Constant (Figure 2)	I_C = 10 mA, I_{B1} = 10 mA, I_{B2} = -10 mA	τ_s	—	18	ns

(1) Pulse Conditions: PW ≤ 300 μs; Duty Cycle ≤1%

MPS3693 (SILICON)
MPS3694



Style 1:
Pin 1. Emitter
2. Base
3. Collector

CASE 29-02
TO-92

NPN silicon annular amplifier transistors designed for general purpose RF amplifier applications in frequency range to 50 MHz. These devices are particularly well suited for use in AM/FM receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C — 8.0 mW/°C, $T_J = -65$ to +150°C, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (2) ($I_C = 10$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	45	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BV_{CBO}	45	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$) ($V_{CB} = 35$ Vdc, $I_E = 0$, $T_A = 65°C$)	I_{CBO}	- -	- -	50 5.0	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) MPS3693 MPS3694	h_{FE}	40 100	- -	160 400	-
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 15$ Vdc, f = 100 MHz)	f_T	200	-	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	-	3.5	pF
Collector-Base Time Constant ($I_E = 10$ mAdc, $V_{CB} = 15$ Vdc, f = 31.8 MHz)	$r'_b C_c$	-	-	55	ps
Noise Figure ($I_C = 3.0$ mAdc, $V_{CE} = 10$ Vdc, $R_S = 300$ ohms, f = 1.0 MHz)	NF	-	4.0	-	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS3702 (SILICON)
MPS3703

PNP silicon annular transistors designed for low-power, large-signal audio applications.



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (2) (I_C = 10 mAdc, I_B = 0)	MPS3702 MPS3703	BV_{CEO}	 25 30	 - -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3702 MPS3703	BV_{CBO}	 40 50	 - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (2) (I_C = 50 mAdc, V_{CE} = 5 Vdc)	MPS3702 MPS3703	h_{FE}	 60 30	 300 150	-
Collector-Emitter Saturation Voltage (2) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage (2) (I_C = 50 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.6	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1 MHz)		C_{ob}	-	12	pF

(2) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3704 (SILICON)
MPS3705
MPS3706

NPN silicon annular transistors designed for low-power, large-signal audio applications.



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	50	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D (1)	310		mW
Derate above 25°C		2.81		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

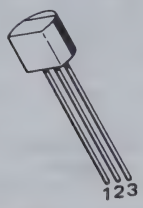
(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, $T_J = -65$ to +150°C, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_E = 0$)	MPS3704	BV_{CEO}	30	-	Vdc
	MPS3705		30	-	
	MPS3706		20	-	
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPS3704	BV_{CBO}	50	-	Vdc
	MPS3705		50	-	
	MPS3706		40	-	
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3$ Vdc, $I_C = 0$)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 50$ mAdc, $V_{CE} = 2$ Vdc)	MPS3704	h_{FE}	100	300	-
	MPS3705		50	150	
	MPS3706		30	600	
Collector-Emitter Saturation Voltage (1) ($I_C = 100$ mAdc, $I_B = 5$ mAdc)	MPS3704	$V_{CE(sat)}$	-	0.6	Vdc
	MPS3705		-	0.8	
	MPS3706		-	1.0	
Base-Emitter On Voltage (1) ($I_C = 100$ mAdc, $V_{CE} = 2$ Vdc)		$V_{BE(on)}$	0.5	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 2$ Vdc, $f = 20$ MHz)		f_T	100	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1$ MHz)		C_{ob}	-	12	pF

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3707 (SILICON)
MPS3708
MPS3709
MPS3710
MPS3711



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon epitaxial transistors designed for general-purpose, low-level amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D (1)	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J (1)	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	$^oC/W$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	30	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 6 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5 Vdc)	MPS3707	h_{FE}	100	400	-
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MPS3708		45	660	
	MPS3709		45	165	
	MPS3710		90	330	
	MPS3711		180	660	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage (I_C = 1 mAdc, V_{CE} = 5 Vdc)		V_{BE}	0.5	1.0	Vdc
Small Signal Current Gain (I_C = 100 μAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3707	h_{FE}	100	550	-
(I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3708		45	800	
	MPS3709		45	250	
	MPS3710		90	450	
	MPS3711		180	800	
Noise Figure (V_{CE} = 5 V, I_C = 100 μA, R_G = 5 kΩ, Noise Bandwidth = 15.7 kHz) Note 1	MPS3707	NF	-	5.0	dB

Note 1 Average Noise Figure is measured in an amplifier with low frequency response down 3 dB at 10 Hz.

MPS3721 (SILICON)

For Specifications, See MPS2926 Data.

MPS4354 (SILICON)
MPS4355
MPS4356

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, low-noise amplifier and high-current switching applications.

- High Breakdown Voltages –
  BV_{CEO} = 60 and 80 Vdc (Min) @ I_C = 10 mAdc
  BV_{CBO} = 60 and 80 Vdc (Min) @ I_C = 10 μAdc
- Excellent Current Gain Linearity Specified –
  100 μAdc to 500 mAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 100 μAdc, f = 100 Hz
- Low Saturation Voltages – MPS4355
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 1.0 Adc
  $V_{BE(sat)}$ = 1.2 Vdc (Max) @ I_C = 1.0 Adc

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

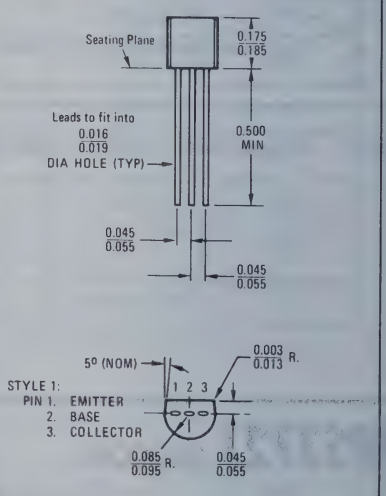


MAXIMUM RATINGS

Rating	Symbol	MPS4354 MPS4355	MPS4356	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	°C/W



All JEDEC dimensions and notes apply

CASE 29-02
TO-92
PLASTIC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPS4354,MPS4355	BV_{CEO}	60	–	–	Vdc
	MPS4356		80	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS4354,MPS4355	BV_{CBO}	60	–	–	Vdc
	MPS4356		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +75°C)			–	–	5.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356	h_{FE}	25	–	–	–
	MPS4355		60	–	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		40	–	–	
	MPS4355		75	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS4354		50	–	500	
	MPS4355		100	–	400	
	MPS4356		50	–	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		40	–	–	
	MPS4355		75	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		30	–	–	
	MPS4355		75	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	–	0.15	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MPS4355		–	–	1.0	
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	–	0.9	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	1.1	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MPS4355		–	–	1.2	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 0.5 Vdc)		$V_{BE(on)}$	–	–	1.1	Vdc
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MPS4355		–	–	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	–	500	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	–	30	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	–	–	110	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	–	550	–	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	100	–	X 10^{-6}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	–	200	–	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	100	–	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz		NF	–	–	3.0	dB
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)		t_{on}	–	–	100	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	–	–	400	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

TYPICAL DYNAMIC CHARACTERISTICS

NOISE FIGURE

FIGURE 1 – SOURCE RESISTANCE EFFECTS

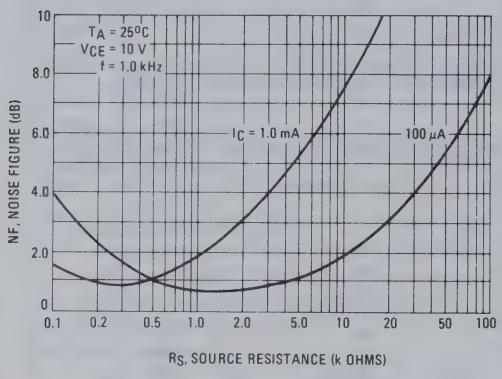


FIGURE 2 – FREQUENCY EFFECTS

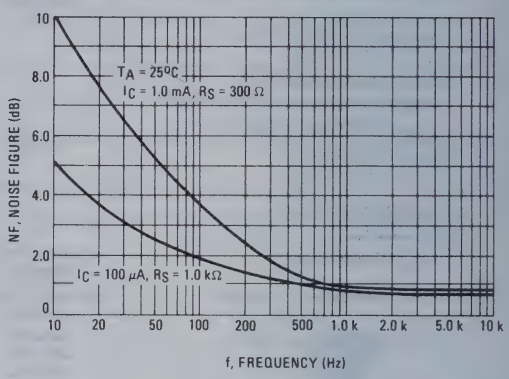


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

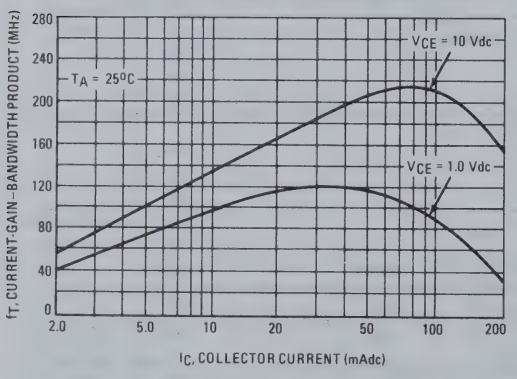


FIGURE 4 – CAPACITANCES

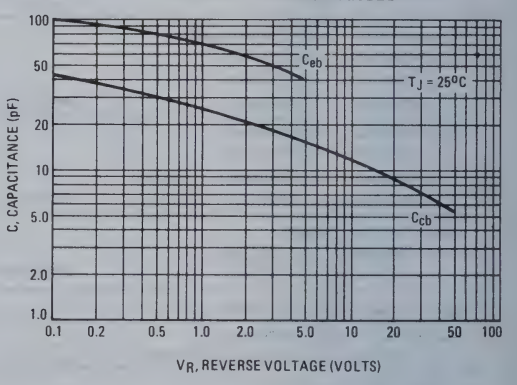


FIGURE 5 – SWITCHING TIMES

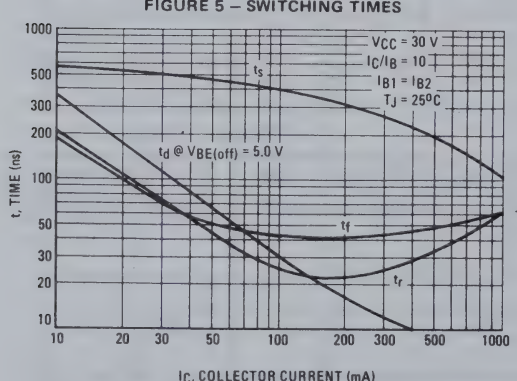
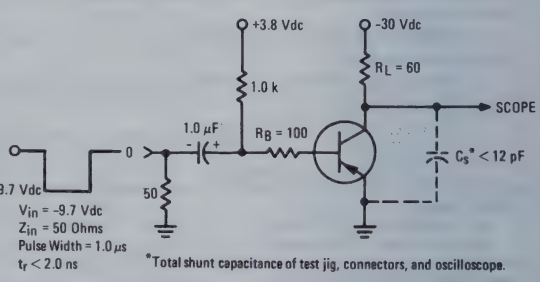


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



TYPICAL DC CHARACTERISTICS

DC CURRENT GAIN

FIGURE 7 – MPS4354, MPS4356

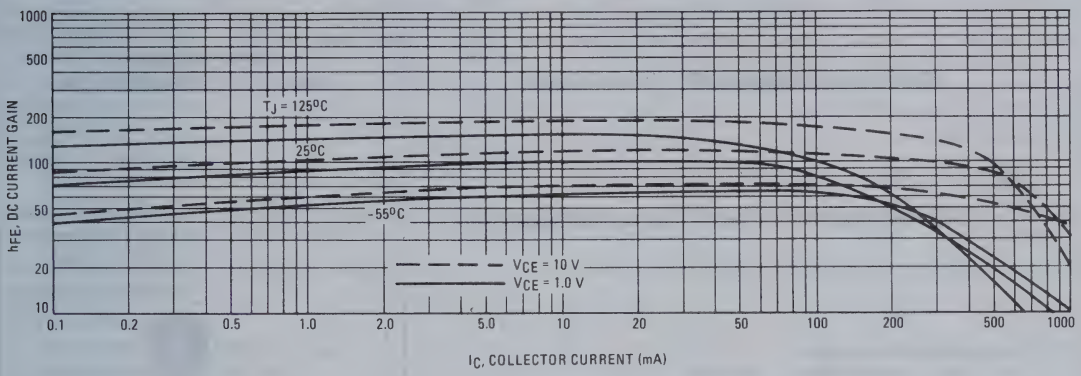


FIGURE 8 – MPS4355

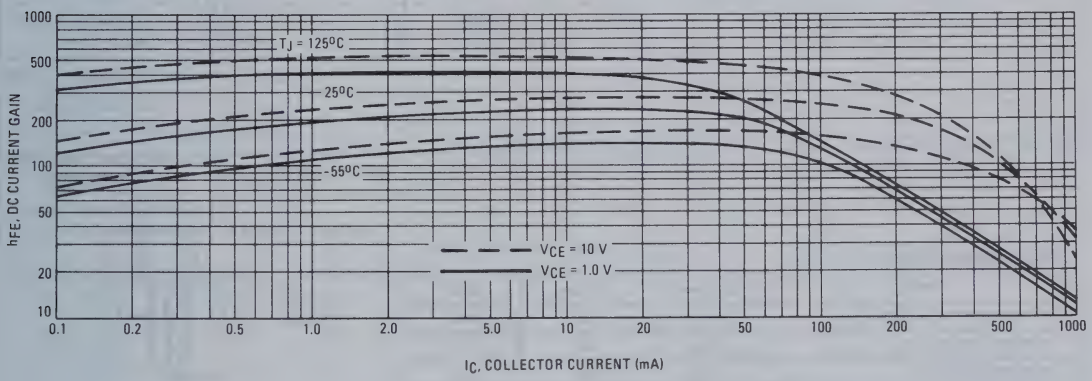


FIGURE 9 – "ON" VOLTAGES

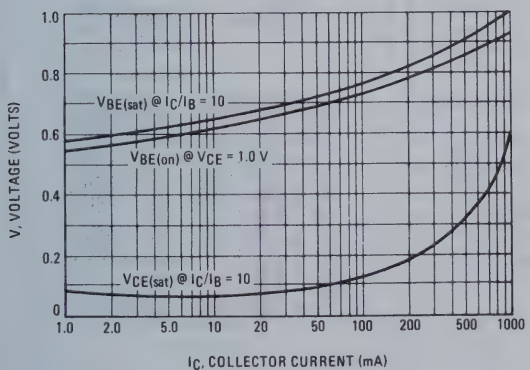
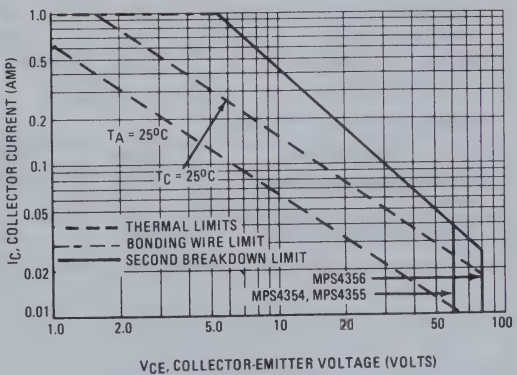


FIGURE 10 – DC SAFE OPERATING AREA



MPS5172 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, low-level amplifier applications.

- High DC Current Gain –
  h_{FE} = 100 - 500 @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc

NPN SILICON AMPLIFIER TRANSISTOR

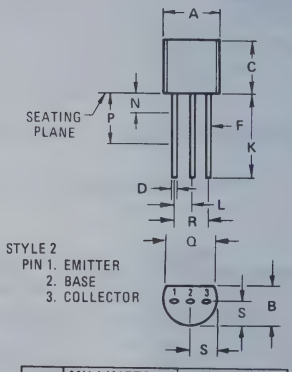


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	nAdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 25 Vdc, I_E = 0)		–	–	100	nAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	–	500	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.75	–	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.5	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	f_T	–	120	–	MHz
Collector-Base Capacitance (V_{CB} = 0, I_E = 0, f = 1.0 MHz)	C_{cb}	1.6	–	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	–	750	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MPS6507 (SILICON)



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon transistor designed as a VHF mixer in TV applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mA
Total Device Dissipation @ T_A = 60°C @ T_A = 25°C	P_D(1)	210 310	mW
Thermal Resistance, Junction to Ambient	θ_{JA}(1)	0.357	°C/mW
Junction Temperature	T_J(1)	135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage(2) (I_C = 10 mAdc, V_{EB} = 0)	BV_{CES}*	30	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 60 °C)	I_{CBO}	— —	— —	0.05 1.0	μAdc
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
High Frequency Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 44 MHz)	$\|h_{fe}\|$	20	—	—	dB
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	2.5	pF
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	700	—	—	MHz
Conversion Gain (See Figures 7, 8, 9) (I_C = 3 mAdc, V_{CE} = 10 Vdc, 213 to 44 MHz)		—	23	—	dB

(2) Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle ≤ 2%

FIGURE 1 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

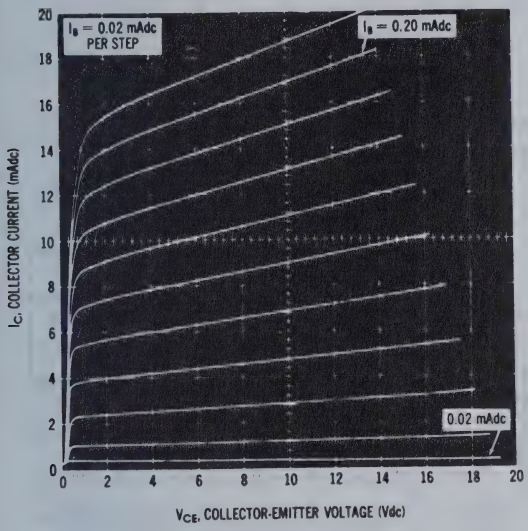
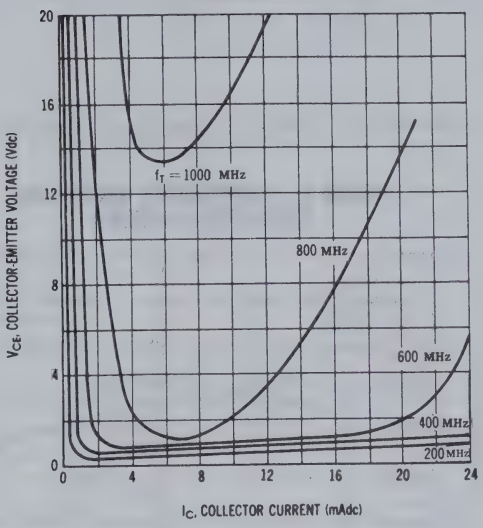


FIGURE 2 — CONTOURS OF CONSTANT GAIN–BANDWIDTH PRODUCT



y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 3 mAdc, T_A = 25°C)

FIGURE 3 — y_{ie}, INPUT ADMITTANCE versus FREQUENCY

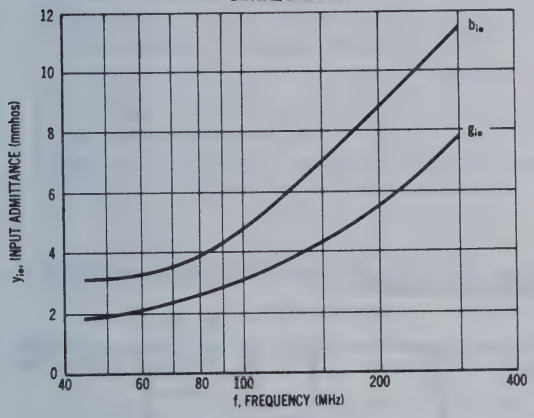


FIGURE 4 — y_{re}, REVERSE TRANSFER ADMITTANCE versus FREQUENCY

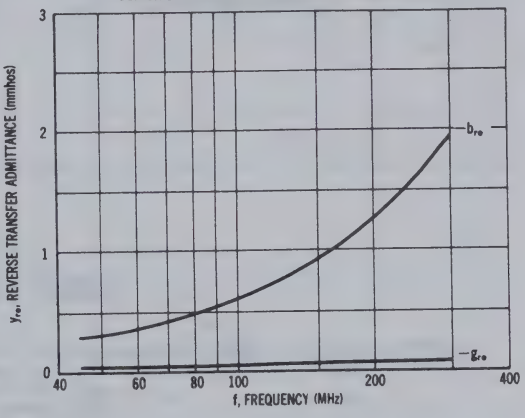


FIGURE 5 — y_{fe}, FORWARD TRANSFER ADMITTANCE versus FREQUENCY

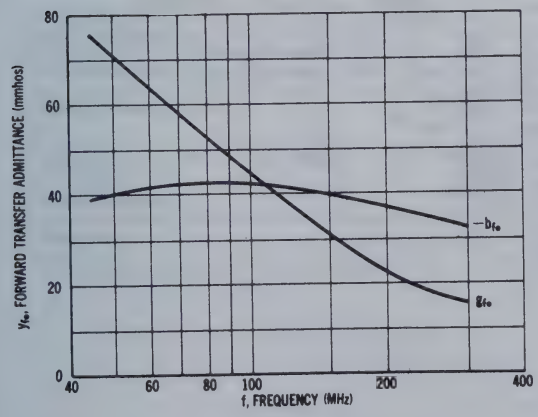


FIGURE 6 — y_{oe}, OUTPUT ADMITTANCE versus FREQUENCY

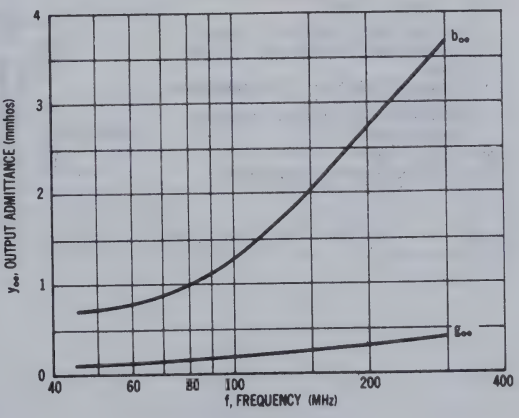


FIGURE 7 — CONVERSION GAIN versus COLLECTOR CURRENT

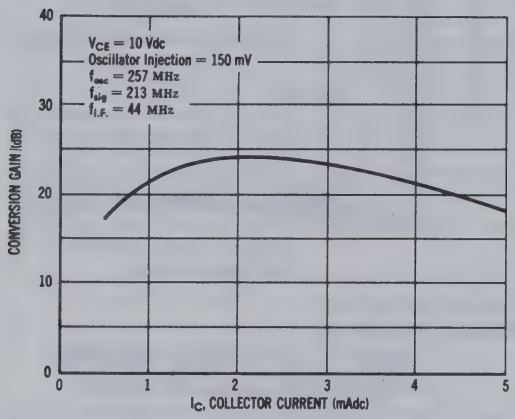


FIGURE 8 — CONVERSION GAIN versus OSCILLATOR INJECTION

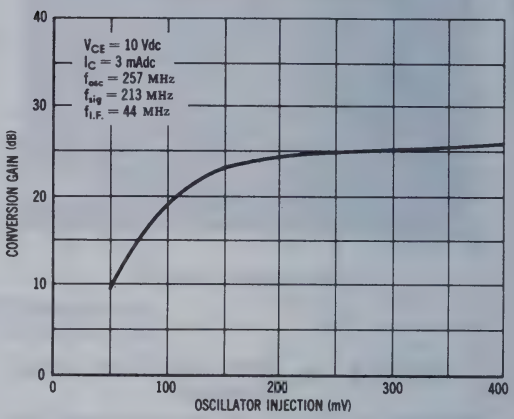
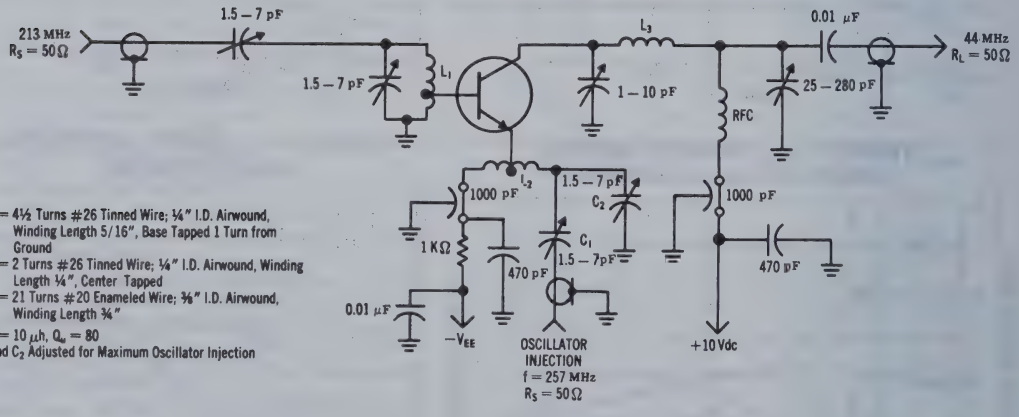


FIGURE 9 — MIXER TEST CIRCUIT



L_1 = 4½ Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length 5/16", Base Tapped 1 Turn from Ground
L_2 = 2 Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length ¼", Center Tapped
L_3 = 21 Turns #20 Enameled Wire; ⅜" I.D. Airwound, Winding Length ¾"
RFC = 10 μh, Q_w = 80
C_1 and C_2 Adjusted for Maximum Oscillator Injection

MPS6511 (SILICON)



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

NPN silicon transistor designed for use in non-AGC IF applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CES}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mAdc
Total Device Dissipation @ T_A = 60°C @ T_A = 25°C	P_D (1)	210 310	mW
Junction Temperature	T_J (1)	135	°C

THERMAL RESISTANCE

$$\theta_{JA(air)} = 0.357\,^{\circ}C/mW$$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}*	I_C = 10 mAdc, V_{EB} = 0	30	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 0.5 mAdc, I_B = 0	20	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_A = 60°C	— —	0.05 1.0	μAdc
Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 10 mAdc	25	—	—
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	—	2.5	pF
Power Gain	G_{pe}	V_{CC} = 12 Vdc, I_C = 10 mAdc, f = 45 MHz (Figure 1)	30	—	dB

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%.

FIGURE 1 – 45 MHz POWER GAIN TEST CIRCUIT

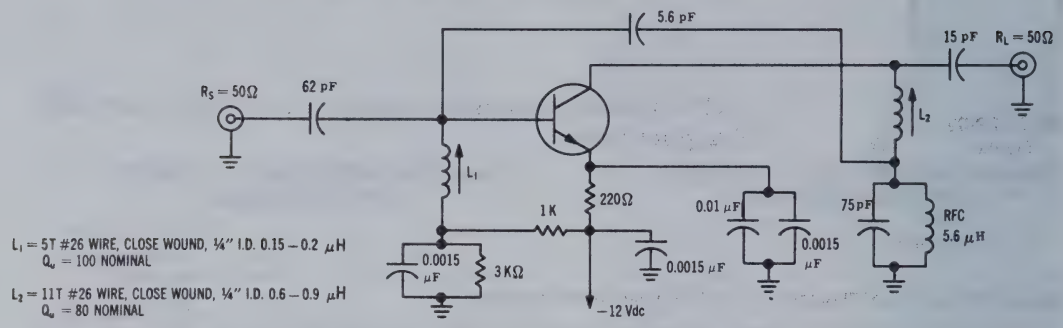


FIGURE 2 — CONTOURS OF CONSTANT GAIN — BANDWIDTH PRODUCT

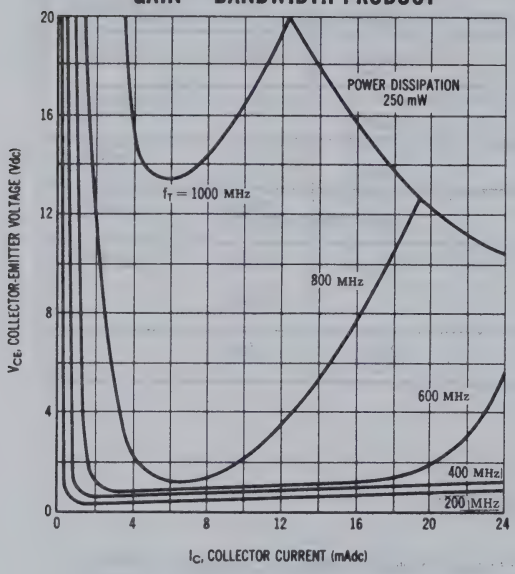


FIGURE 3 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

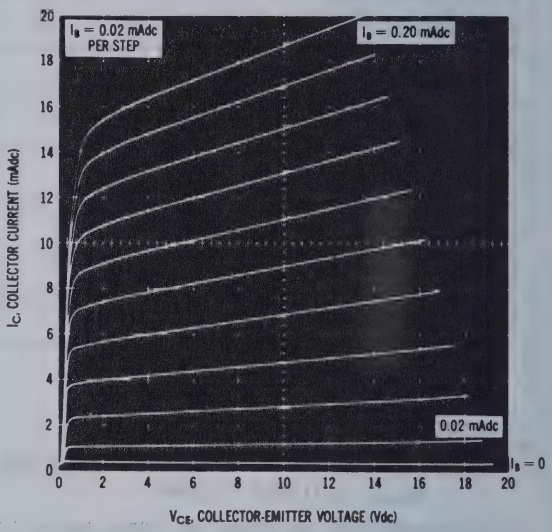


FIGURE 4 — INPUT ADMITTANCE versus COLLECTOR CURRENT

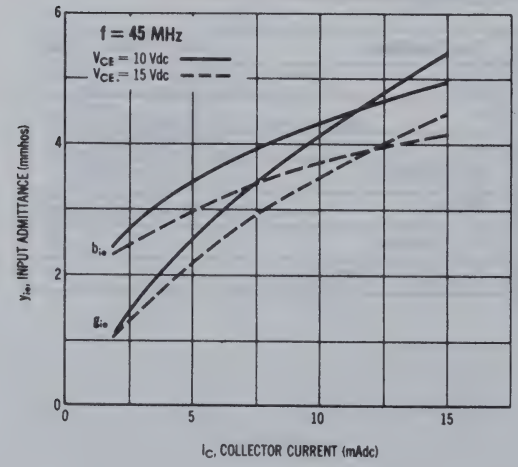


FIGURE 5 — REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

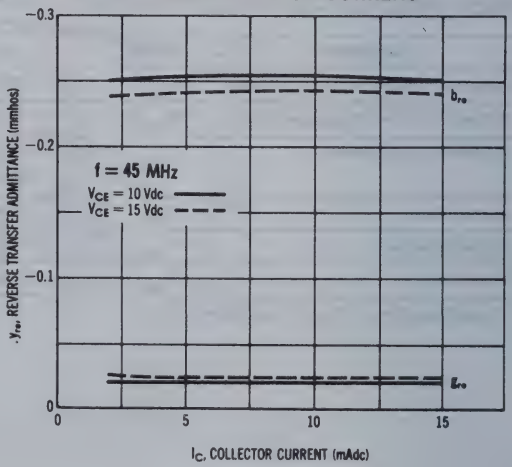


FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

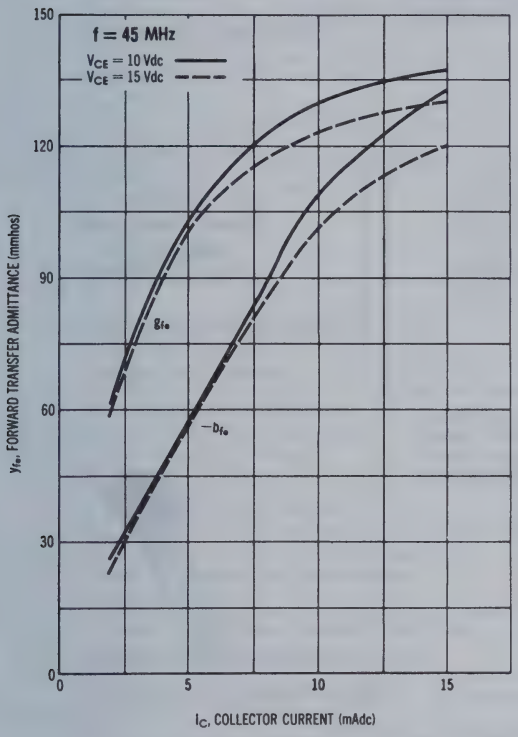


FIGURE 7 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

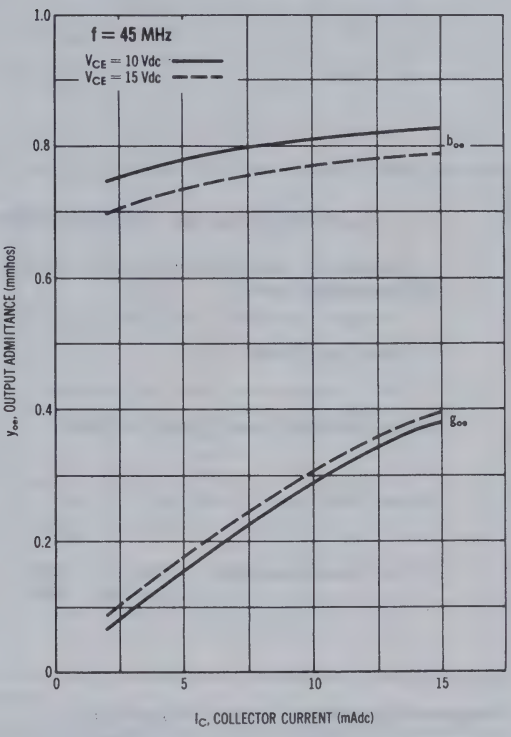
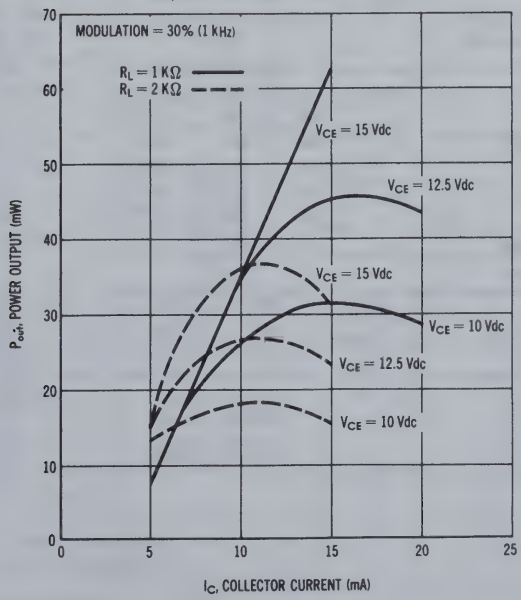


FIGURE 8 — POWER OUTPUT versus COLLECTOR CURRENT

(FOR 3% ENVELOPE DISTORTION)



MPS6512 thru MPS6515 NPN (SILICON)
MPS6516 thru MPS6519 PNP (SILICON)

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- Narrow Gain Ranges – 2:1
- Complementary Types for Each Gain Range
- Low Noise Figure – 2.0 dB Typ
- Low Output Capacitance – 3.5 pF Max – NPN
  4.0 pF Max – PNP

SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS



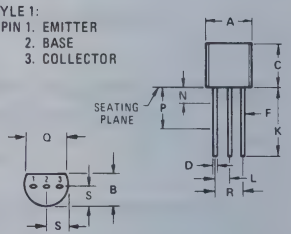
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6512, MPS6513		30	–	
MPS6514, MPS6515		25	–	
MPS6516 thru MPS6518		–	40	
MPS6519		–	25	
Collector-Base Voltage	V_{CB}			Vdc
MPS6512 thru MPS6515		40	–	
MPS6516 thru MPS6518		–	40	
MPS6519		–	25	
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current	I_C	100	100	mAdc
Total Power Dissipation @ T_A = 25°C	P_D	350	350	mW
Derate above 25°C		2.8	2.8	mW/°C
Total Power Dissipation @ T_C = 25°C	P_D	1.0	1.0	Watt
Derate above 25°C		8.0	8.0	mW/°C
Operating Junction Temperature Range	T_J	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPS6512 thru MPS6515/MPS6516 thru MPS6519 (continued)

MPS6512 thru MPS6515 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513	BV_{CEO}	30	-	-	Vdc
	MPS6514, MPS6515		25	-	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	-	0.05	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			-	-	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512	h_{FE}	50	-	100	-
	MPS6513		90	-	180	
	MPS6514		150	-	300	
	MPS6515		250	-	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*	MPS6512		30 *	-	-	
	MPS6513		60 *	-	-	
	MPS6514		90 *	-	-	
	MPS6515		150 *	-	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513	f_T	-	250	-	MHz
	MPS6514, MPS6515		-	390	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513		-	330	-	
	MPS6514, MPS6515		-	480	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	-	2.0	-	dB

* Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 2.0%.

MPS6516 thru MPS6519 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518	BV_{CEO}	40	-	-	Vdc
	MPS6519		25	-	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	MPS6516 thru MPS6518	I_{CBO}	-	-	0.05	μAdc
(V_{CB} = 20 Vdc, I_E = 0)	MPS6519		-	-	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	MPS6516 thru MPS6518		-	-	1.0	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	MPS6519		-	-	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516	h_{FE}	50	-	100	-
	MPS6517		90	-	180	
	MPS6518		150	-	300	
	MPS6519		250	-	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*	MPS6516		30 *	-	-	
	MPS6517		60 *	-	-	
	MPS6518		90 *	-	-	
	MPS6519		150 *	-	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517	f_T	-	200	-	MHz
	MPS6518, MPS6519		-	340	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517		-	270	-	
	MPS6518, MPS6519		-	420	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	-	2.0	-	dB

* Pulse Test: Pulse Width ≤ 30 μs, Duty Cycle ≤ 2.0%.

MPS6520, MPS6521 NPN (SILICON)
MPS6522, MPS6523 PNP

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- High DC Current Gain –
  h_{FE} = 150 (Min) @ I_C = 100 μAdc – MPS6521, MPS6523
- Low Noise Figure –
  NF = 1.8 dB (Typ) @ I_C = 10 μAdc
- Low Output Capacitance –
  C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 Vdc

SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS

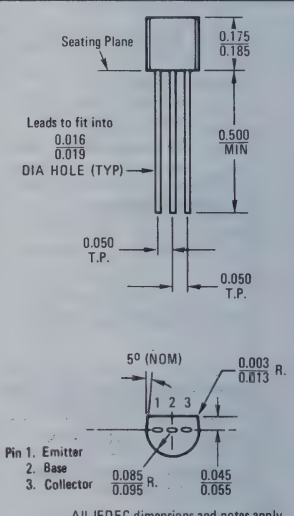


MAXIMUM RATING

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CEO}	 25	 25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CB}	 40	 25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current – Continuous	I_C	100	100	mAdc
Total Device Dissipation @ T_A = 25°C T_A = 60°C Derate above 25°C	P_D	310 210 2.81	310 210 2.81	mW mW/°C
Operating Junction Temperature Range	T_J	135	135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R\theta_{JA}$	0.357	°C/mW



All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

MPS6520, MPS6521 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520		100	–	–	
	MPS6521		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520		200	–	400	
	MPS6521		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	390	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	480	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

MPS6522, MPS6523 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 20 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522		100	–	–	
	MPS6523		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6522		200	–	400	
	MPS6523		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	340	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	420	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

MPS6530
MPS6531
MPS6532
NPN (SILICON)

MPS6533
MPS6534
MPS6535
PNP



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

Silicon annular transistors designed for use in complementary amplifier circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	NPN	PNP	Unit
Collector-Base Voltage	V_{CB}			Vdc
MPS6530, MPS6531 MPS6532		60 50		
MPS6533, MPS6534 MPS6535			40 30	
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6530, MPS6531 MPS6532		40 30		
MPS6533, MPS6534 MPS6535			40 30	
Emitter-Base Voltage	V_{EB}	5.0	4.0	Vdc
Collector Current - Continuous	I_C	600	600	mAdc
Total Device Dissipation @ T_A = 60°C	P_D (1)	210	210	mW
@ T_C = 25°C		310	310	
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	0.357	°C/mW
Junction Temperature	T_J (1)	135	135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = −65 to +150°C, θ_{JC} = 125° C/W.

MPS6530 thru MPS6532 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6530, MPS6531 MPS6532	BV_{CBO}	60 50	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6530, MPS6531 MPS6532	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	 MPS6530, MPS6531 MPS6532 MPS6530, MPS6531 MPS6532	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6530 MPS6531 MPS6530 MPS6531 MPS6532 MPS6530 MPS6531	h_{FE}	 30 60 40 90 30 25 50	 75 120 85 150 - 60 80	 - - 120 270 - - -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	- -	0.82 0.85	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	3.5	5.0	pF
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	390	-	MHz

MPS6533 thru MPS6535 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6533, MPS6534 MPS6535	BV_{CBO}	40 30	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6533, MPS6534 MPS6535	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	 MPS6533, MPS6534 MPS6535 MPS6533, MPS6534 MPS6535	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6533 MPS6534 MPS6533 MPS6534 MPS6535 MPS6533 MPS6534	h_{FE}	 30 60 40 90 30 25 50	 70 110 85 140 - 55 70	 - - 120 270 - - -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	- -	0.84 0.87	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.8	6.0	pF
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	260	-	MHz

MPS6539 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for RF applications in FM receivers.

. Low Feedback Capacitance
C_{cb} = 0.7 pF max

. High Gain - Bandwidth Product
f_T = 500 MHz

. Low Noise Figure
NF = 4.5 dB max @ 100 MHz

NPN SILICON RF AMPLIFIER TRANSISTOR

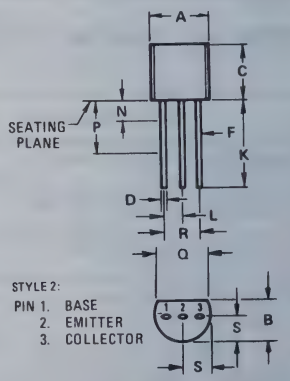


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

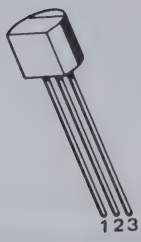
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 mHz)	f_T	500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b{}'C_c$	-	9.0	ps
Noise Figure (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz)	NF	-	4.5	dB

MPS6540 (SILICON)

NPN silicon annular amplifier transistor designed for IF applications in FM radio receivers.



CASE 29(2)
TO-92
Pin 1. Base
2. Emitter
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}(1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}(1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	-	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	-	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	-	0.65	pF
Real Part of Output Impedance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 10.7 MHz)	R_{oep}	80	-	-	k ohms
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	4.5	-	ps
FUNCTIONAL TESTS					
Maximum Available Gain (f = 10.7 MHz)	MAG	-	48	-	dB

COMMON-EMITTER y PARAMETERS

(V_{CE} = 10 Vdc, f = 10.7 MHz, T_A = 25°C)

FIGURE 1 — INPUT ADMITTANCE

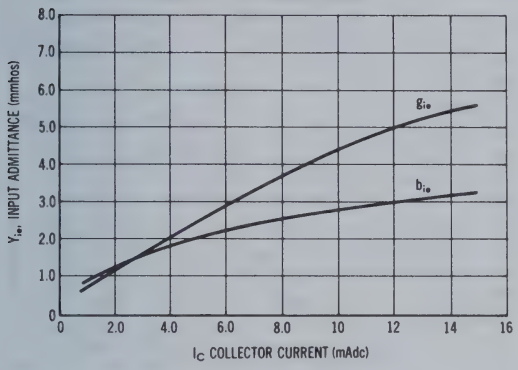


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

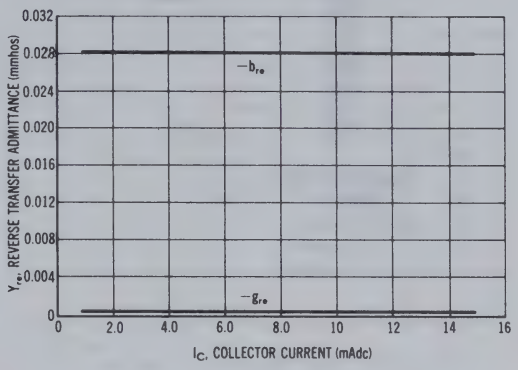


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

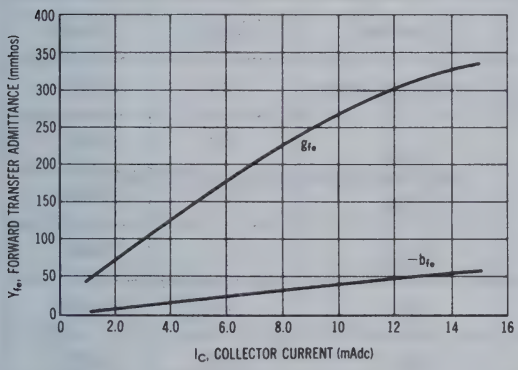


FIGURE 4 — OUTPUT ADMITTANCE

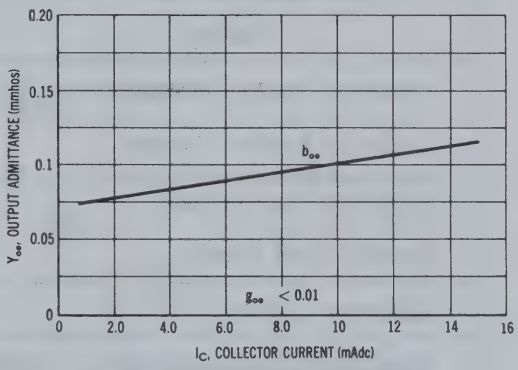


FIGURE 5 — CAPACITANCES

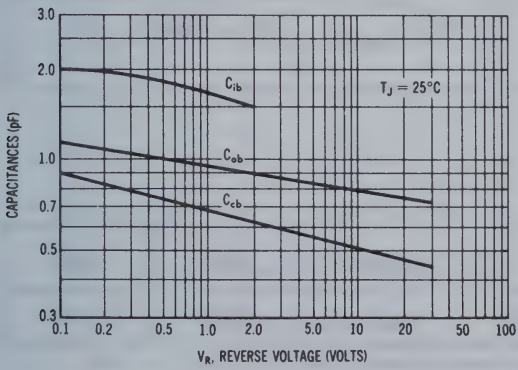
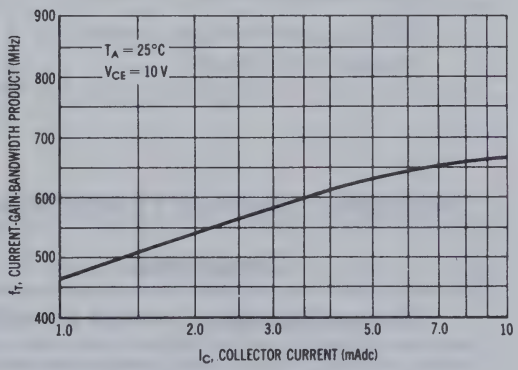


FIGURE 6 — CURRENT-GAIN—BANDWIDTH PRODUCT



MPS6542 (SILICON)



CASE 29(2)
TO-92
Pin 1. Base
2. Emitter
3. Collector

NPN silicon epitaxial transistor designed for VHF mixer applications in TV receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D (1)	310 2.81	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	$^oC/mW$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25^oC$, Derate above $25^oC - 8.0$ mW/^oC, $T_J = -65$ to $+150^oC$, $\theta_{JC} = 125^oC/W$.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	30	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.05	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 60°C)		—	—	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	—	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc)	C_{re}	—	0.33	—	pF
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	1.5	pF
High-Frequency Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 44 MHz)	h_{fe}	10	—	—	—
Conversion Gain (213 to 44 MHz) (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, See Figures 1, 2, & 9)	—	20	23	—	dB

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 — VARIATION WITH COLLECTOR CURRENT

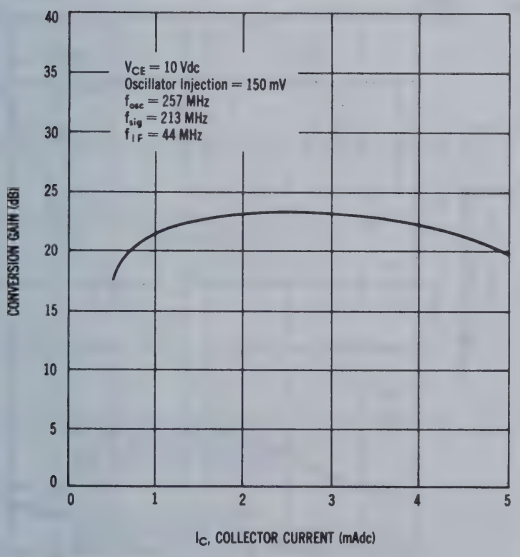
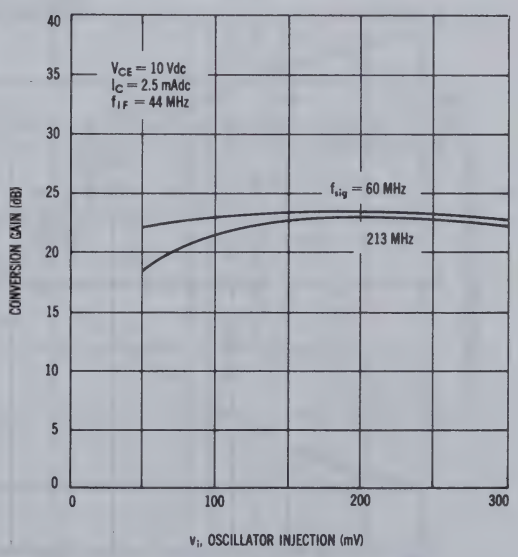


FIGURE 2 — VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

$I_C = 2.5$ mAdc, $V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 3 — INPUT ADMITTANCE

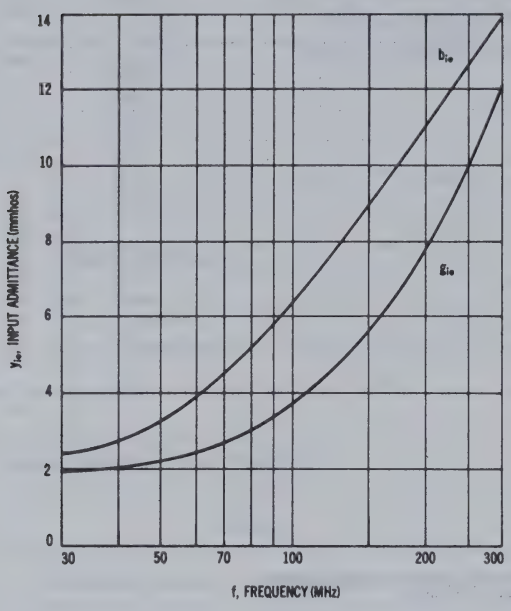


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

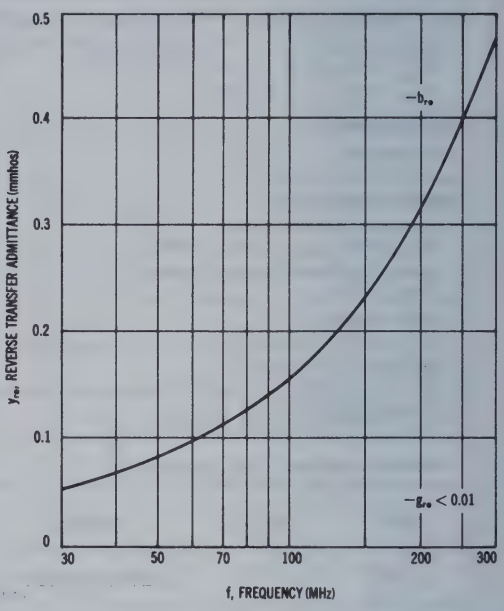


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

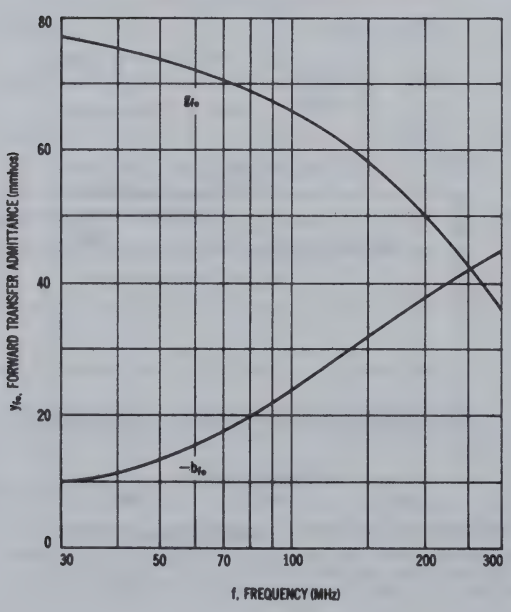


FIGURE 6 — OUTPUT ADMITTANCE

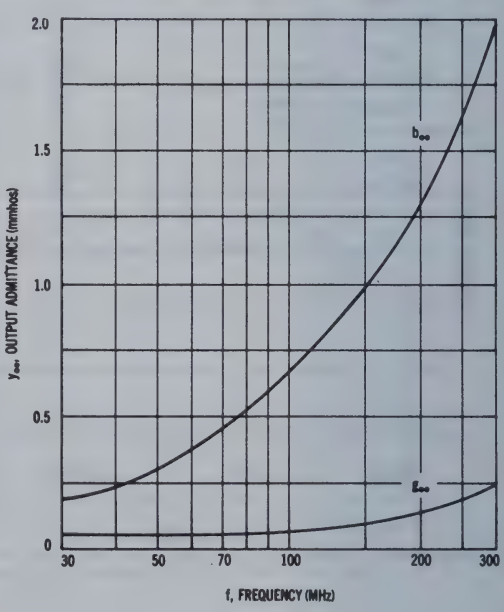


FIGURE 7 — DC CURRENT GAIN

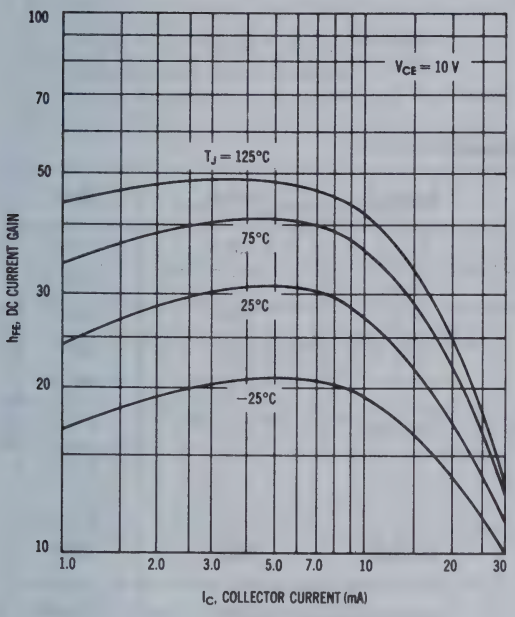


FIGURE 8 — CAPACITANCES

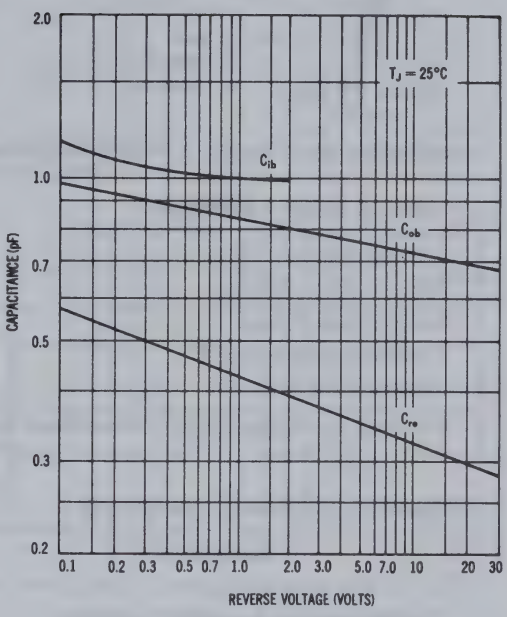
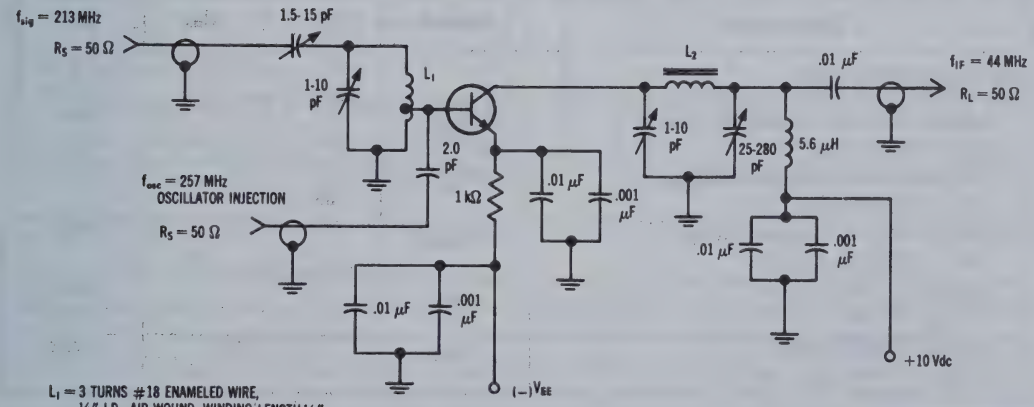


FIGURE 9 — MIXER TEST CIRCUIT



L_1 = 3 TURNS #18 ENAMELED WIRE, ¼" I.D., AIR WOUND, WINDING LENGTH ½"; BASE TAPPED 1 TURN FROM GROUND.

L_2 = 10 TURNS #26 INSULATED WIRE, WOUND ON ¼" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPS6543 (SILICON)



CASE 29 (2)
(TO-92)

NPN silicon epitaxial transistor designed for use in UHF oscillator applications.

Pin 1. Base
2. Emitter
3. Collector

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2 Vdc, I_C = 0)	I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.95	Vdc

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

MPS6543 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	750	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	1.0	pF
Collector-Base Time Constant (I_E = 4 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.5	ps

COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, f = 930 MHz, T_A = 25°C

FIGURE 1—INPUT ADMITTANCE

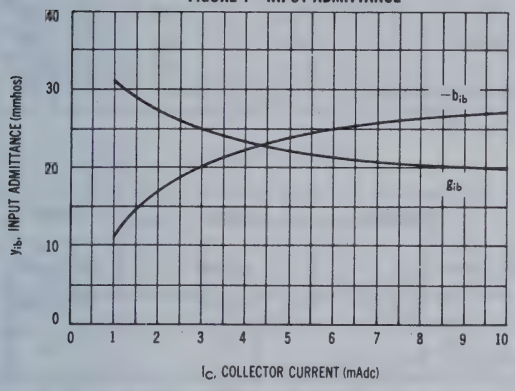


FIGURE 2—REVERSE TRANSFER ADMITTANCE

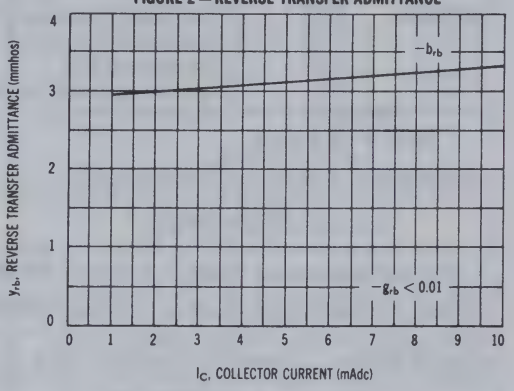


FIGURE 3—FORWARD TRANSFER ADMITTANCE

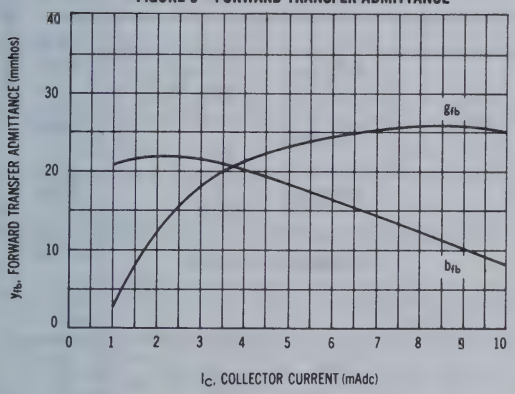


FIGURE 4—OUTPUT ADMITTANCE

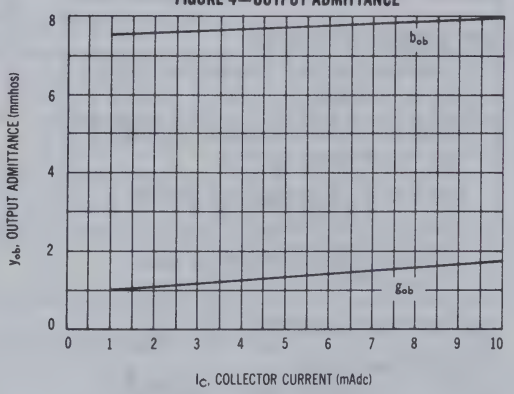


FIGURE 5—CAPACITANCES

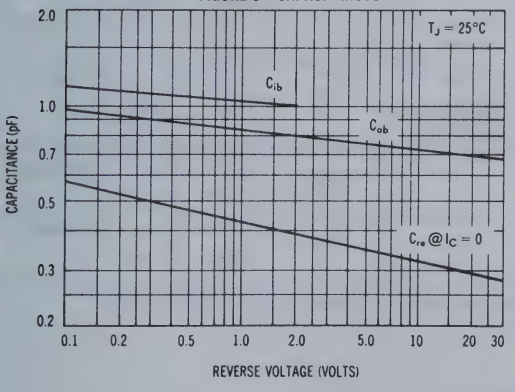
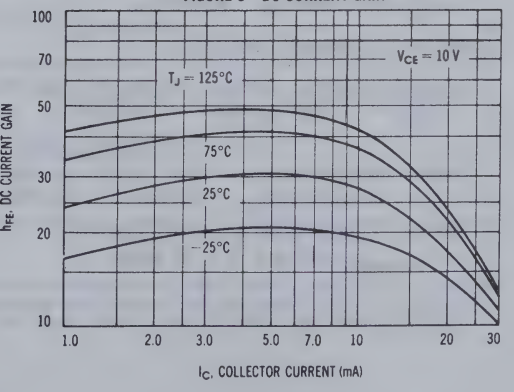


FIGURE 6—DC CURRENT GAIN



MPS6544 (SILICON)
MPS6545

CASE 29 (2)
TO-92
Pin 1. Base
2. Emitter
3. Collector



MPS6544

CASE 29A



MPS6545
TO-92 WITH SHIELD

NPN silicon annular amplifier transistors designed for third-stage video IF applications in television receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 60°C	P_D	210	mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction Ambient - MPS6544	θ_{JA}	0.357	°C/mW
Thermal Resistance, Junction to Case - MPS6545	θ_{JC} (1)	0.150	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	BV_{CEO}	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
DYNAMIC CHARACTERISTICS				
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kHz) MPS6544 MPS6545	C_{re}	— —	0.65 0.58	pF
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 45 MHz)	y_{oe}	—	0.10	mmhos
Output Voltage (Test Circuit Figure 6) ($V_{in(RMS)}$ =12 mV, f = 45 MHz)	V_{out}	1.0	—	Vdc

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

COMMON-EMITTER y PARAMETERS

V_{CE} = 20 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

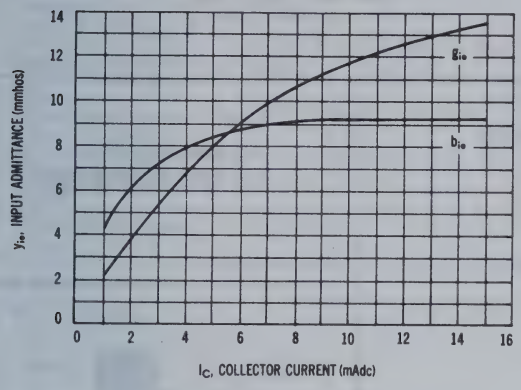


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

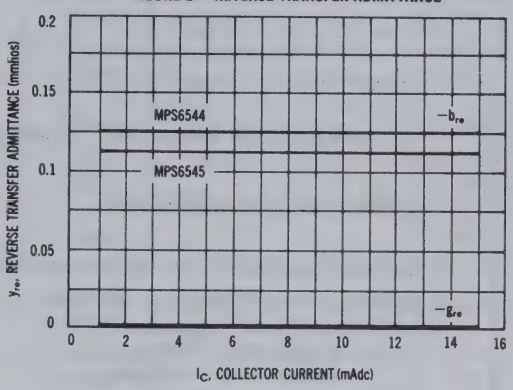


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

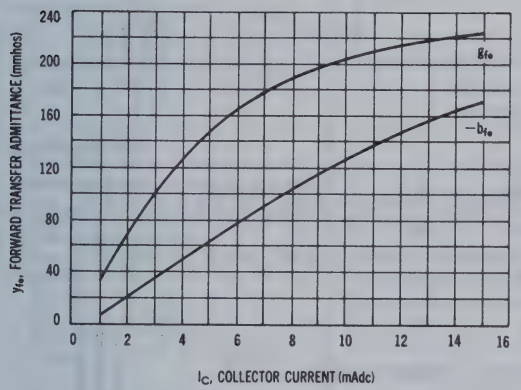


FIGURE 4 — OUTPUT ADMITTANCE

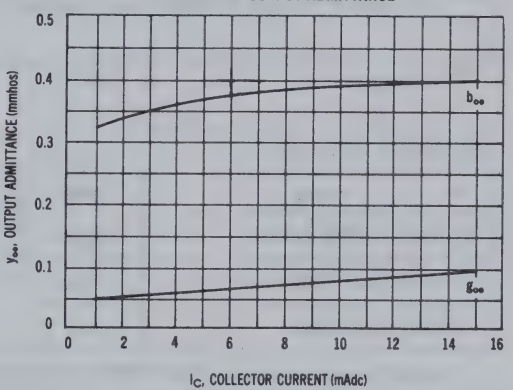


FIGURE 5 — CAPACITANCES

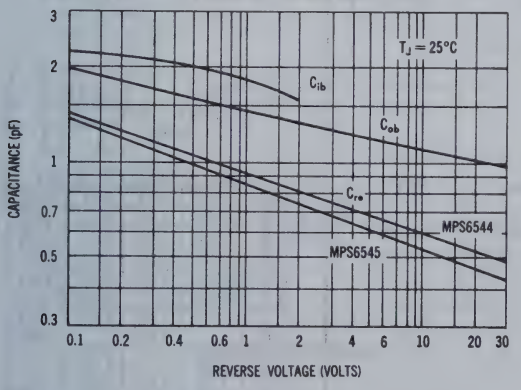
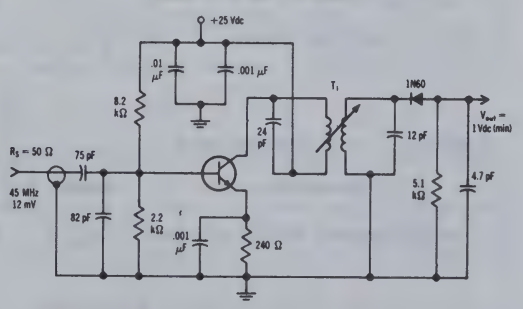


FIGURE 6 — 45 MHz TEST CIRCUIT



T_1 — PRIMARY: 7 TURNS #26 WIRE, ¼" I.D.
SECONDARY: 10 TURNS #26 WIRE, ¼" I.D.
CORE: ARNOLD IRON POWDER, PART NO. A1-10

FOR MPS6545 SHIELD IS CONNECTED TO GROUND

MPS6546 (SILICON)
MPS6547

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for FM radio applications.

- Oscillator Power Output = 10mW minimum – MPS6546
- Conversion Gain - 28 dB (Typ) – MPS6547
- Low Reverse Transfer Capacitance
  C_{re} = 0.35 pF (Max) – MPS6547
  0.45 pF (Max) – MPS6546
- Complete Common-Base and Common-Emitter y-Parameter Curves
- One-Piece, Injection-Molded Unibloc Package

NPN SILICON FM TRANSISTORS

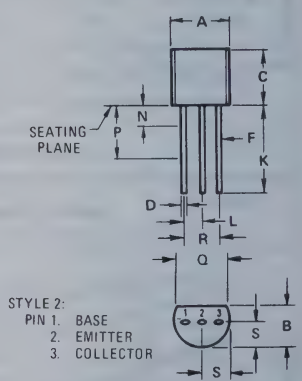


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Collector Current-Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2 Vdc, I_C = 0)		I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	—	0.35	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 100 mHz)		f_T	600	—	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	MPS6547	C_{re}	—	—	0.35	pF
	MPS6546		—	—	0.45	
FUNCTIONAL TEST						
Conversion Gain (108 MHz to 10.7 MHz) (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, Test Circuit Figure 7)	MPS6547	—	—	28	—	dB
Oscillator Power Output (V_{EE} = 12.5 Vdc, f = 118 MHz, Test Circuit Figure 13)	MPS6546	P_{out}	10	18	—	mW

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

FIGURE 1—VARIATION WITH COLLECTOR CURRENT

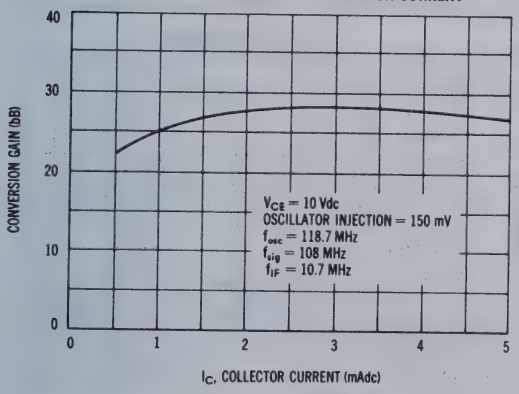
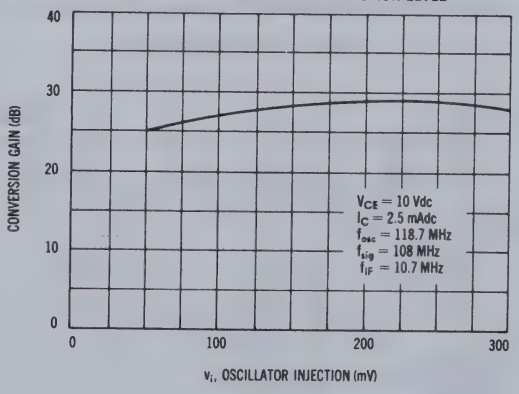


FIGURE 2—VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 Vdc, f = 105 MHz, T_A = 25°C

FIGURE 3—INPUT ADMITTANCE

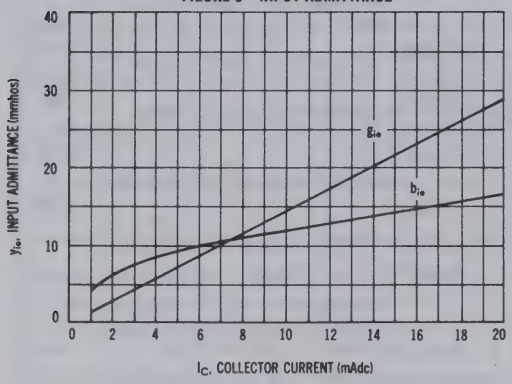


FIGURE 4—REVERSE TRANSFER ADMITTANCE

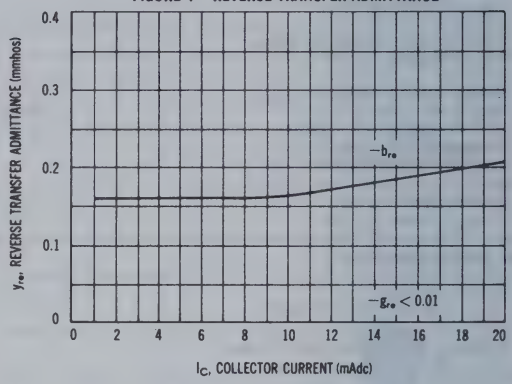


FIGURE 5—FORWARD TRANSFER ADMITTANCE

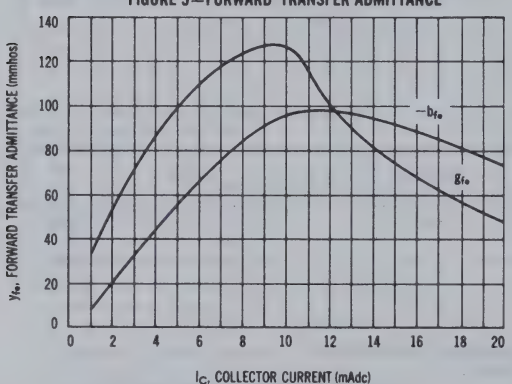


FIGURE 6—OUTPUT ADMITTANCE

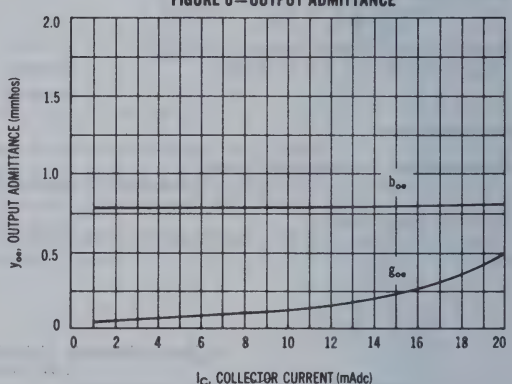


FIGURE 7—MIXER TEST CIRCUIT

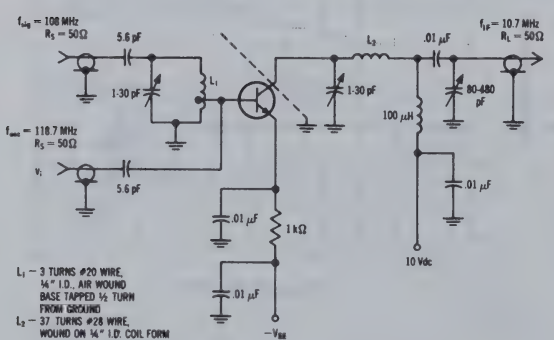
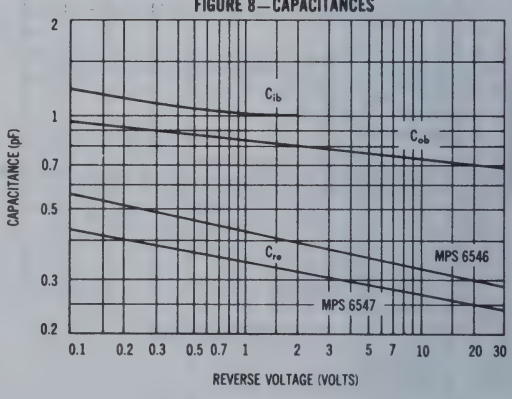


FIGURE 8—CAPACITANCES



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, I_C = 2.5 mAdc, T_A = 25°C

FIGURE 9—INPUT ADMITTANCE

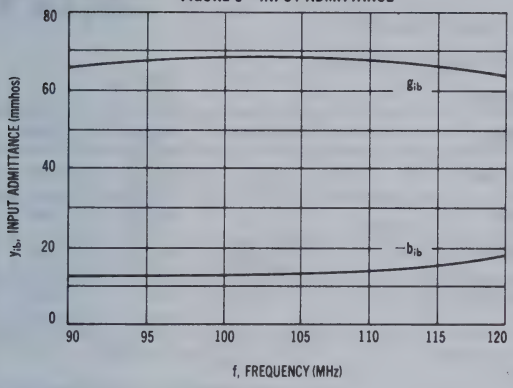


FIGURE 10—REVERSE TRANSFER ADMITTANCE

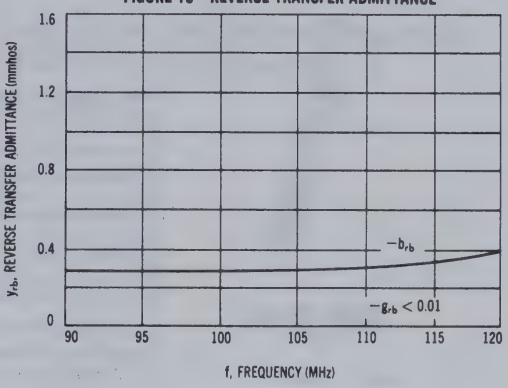


FIGURE 11—FORWARD TRANSFER ADMITTANCE

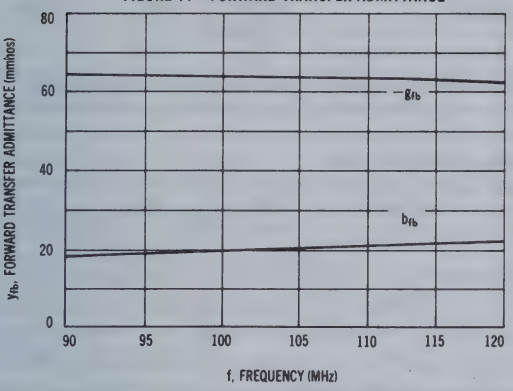
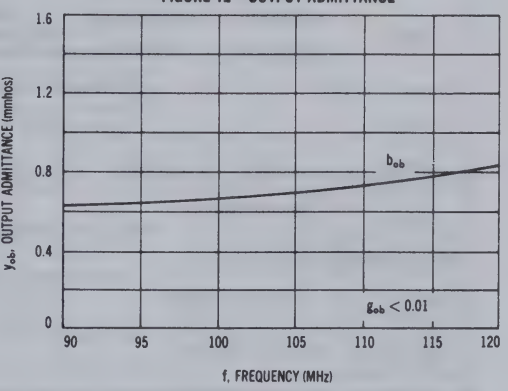


FIGURE 12—OUTPUT ADMITTANCE



TYPICAL OSCILLATOR PERFORMANCE

FIGURE 13—TEST CIRCUIT

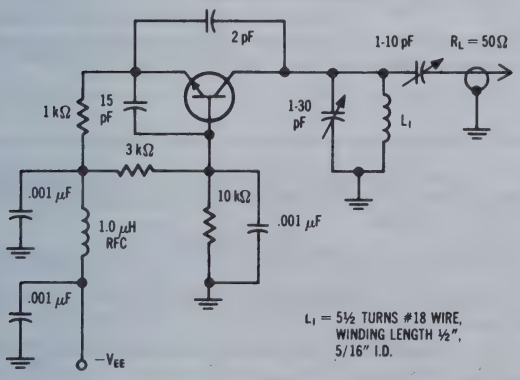
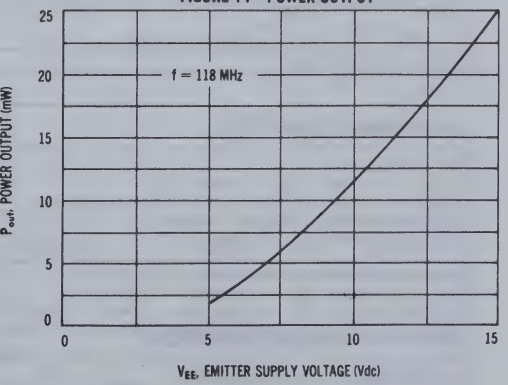


FIGURE 14—POWER OUTPUT



MPS6548 (SILICON)

NPN silicon epitaxial transistor designed for use in UHF oscillator applications.



CASE 29 (2)
TO-92

Pin 1. Base
2. Emitter
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	-	-
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{BE(sat)}$	-	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	9.0	ps

MPS6560 MPS6561 NPN (SILICON)

MPS6562 MPS6563 PNP

Silicon annular audio transistors designed for complementary symmetry audio output applications.



CASE 29-02
TO-92

Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	MPS6560 MPS6562	MPS6561 MPS6563	Unit
Collector-Emitter Voltage	V_{CEO}	25	20	Vdc
Collector-Base Voltage	V_{CB}	25	20	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D[1]	500 4.54		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 7.27		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}[1]	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction To Ambient	$R\theta_{JA}$[1]	0.220	°C/mW
Thermal Resistance, Junction To Case	$R\theta_{JC}$[1]	0.137	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) MPS6561, MPS6563	I_{CEO}	-	100	nAdc
(V_{CE} = 25 Vdc, I_B = 0) MPS6560, MPS6562		-	100	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	35	-	-
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	-	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc) MPS6560, MPS6562		50	200	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc) MPS6561, MPS6563		50	200	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) MPS6560, MPS6562	$V_{CE(sat)}$	-	0.5	Vdc
(I_C = 350 mAdc, I_B = 35 mAdc) MPS6561, MPS6563		-	0.5	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) MPS6560, MPS6562	$V_{BE(on)}$	-	1.2	Vdc
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc) MPS6561, MPS6563		-	1.2	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	30	pF

TYPICAL CHARACTERISTICS

MPS6560
MPS6562

FIGURE 1 — DC CURRENT GAIN

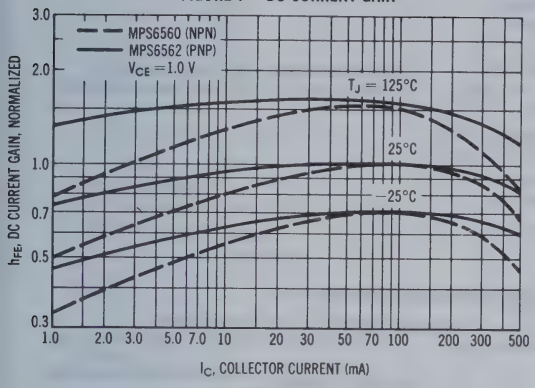


FIGURE 3 — COLLECTOR SATURATION REGION

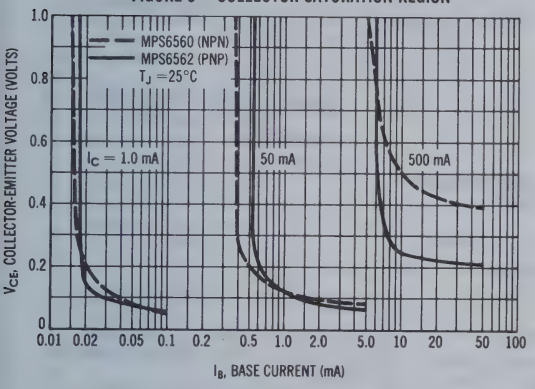
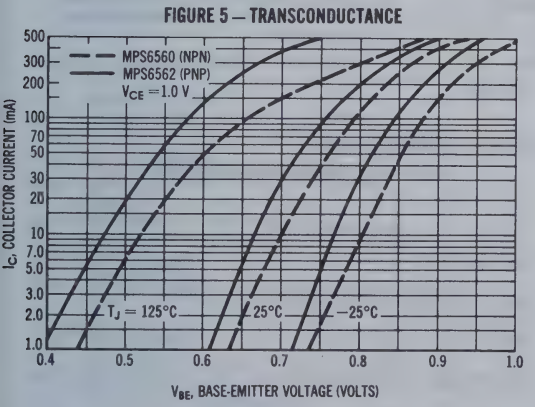


FIGURE 5 — TRANSCONDUCTANCE



MPS6561
MPS6563

FIGURE 2 — DC CURRENT GAIN

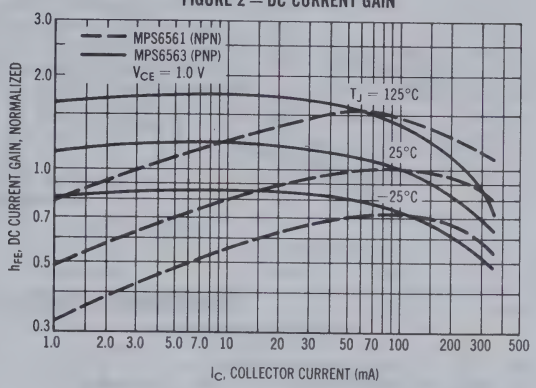


FIGURE 4 — COLLECTOR SATURATION REGION

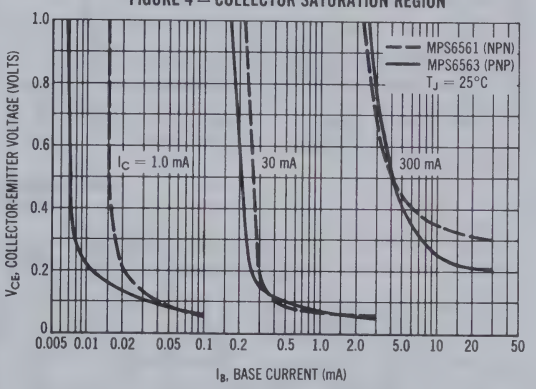
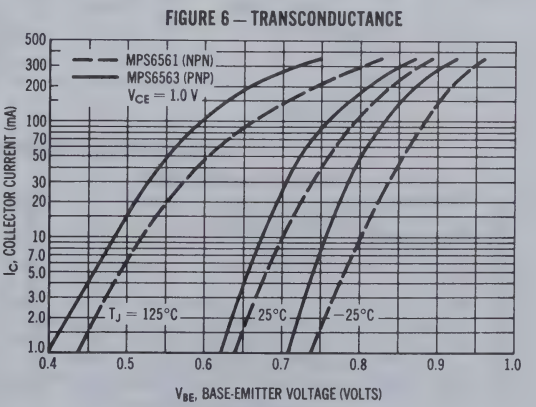
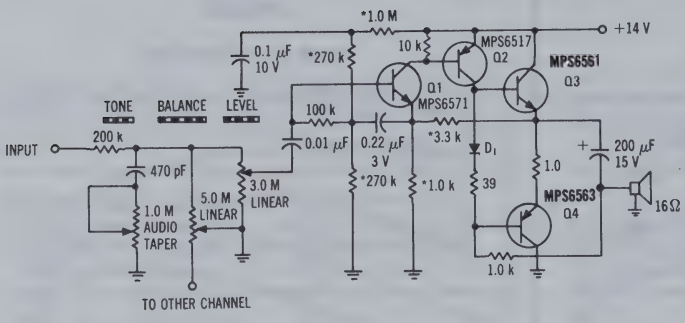


FIGURE 6 — TRANSCONDUCTANCE



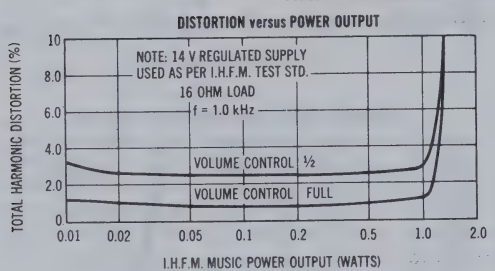
TYPICAL AUDIO APPLICATIONS

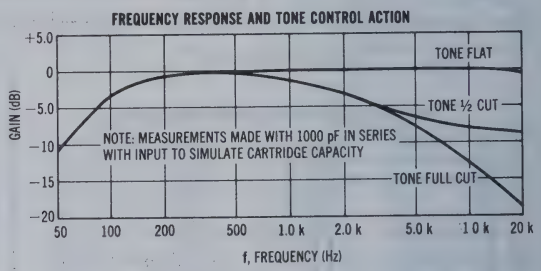
1-WATT STEREOPHONIC AUDIO AMPLIFIER
(ONE CHANNEL SHOWN)



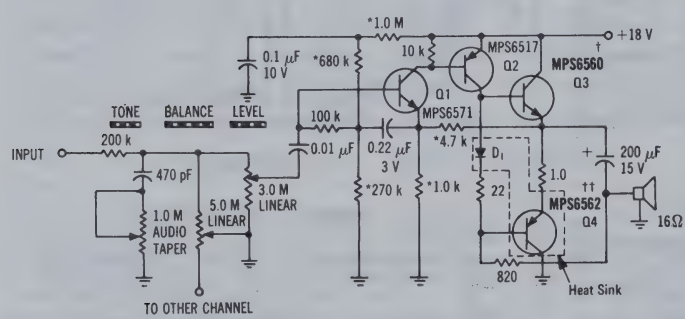
All resistors are ½ Watt, ±10% ratings, except for parts preceded by an asterisk (*) where ±5% types are recommended.
D_1 = MSS1000

TYPICAL PERFORMANCE CURVES FOR 1-WATT/16-OHM AUDIO AMPLIFIER



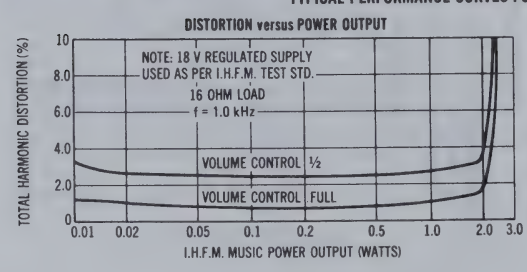


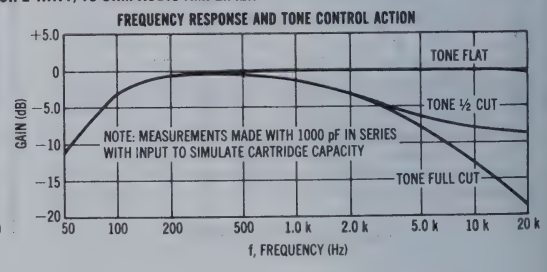
2-WATT STEREOPHONIC AUDIO AMPLIFIER
(ONE CHANNEL SHOWN)



All resistors are ½ Watt, ±10% ratings, except for parts preceded by an asterisk (*) where ±5% types are recommended.
D_1 = MSS1000
†Requires Heat Sink. Use Staver F1-7A (or equivalent).
††Requires Heat Sink. Use Staver F1-8. This Heat Sink allows D_1 and Q4 to be thermally connected, thus enhancing high temperature operation.

TYPICAL PERFORMANCE CURVES FOR 2-WATT/16-OHM AUDIO AMPLIFIER





MPS6565 (SILICON)
MPS6566

NPN silicon annular transistors designed for general-purpose, low-level amplifier applications.



CASE 29-02
TO-92
Style 1:
Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6565	h_{FE}	40	—	160	—
	MPS6566		100	—	400	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.1	0.4	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	3.7	—	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	2.0	—	—	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{oe}	—	60	—	μmhos
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{ie}	—	500	—	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{re}	—	2.5	—	X 10^{-4}
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1000 ohms, f = 10 Hz to 15.7 kHz)		NF	—	4.0	—	dB

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 1 — FREQUENCY EFFECTS

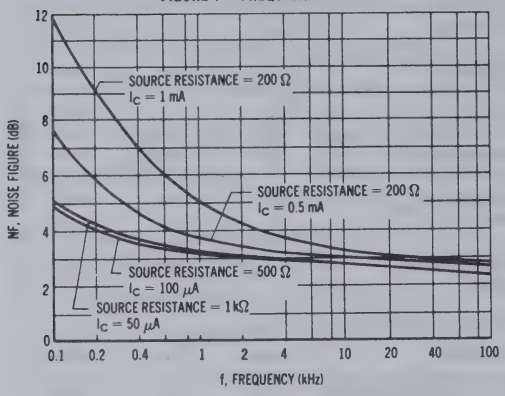
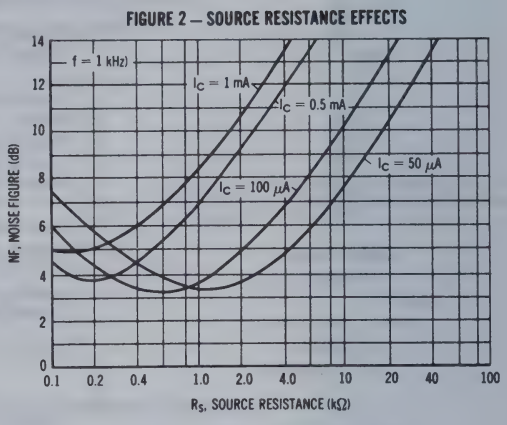


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 3 — CURRENT GAIN

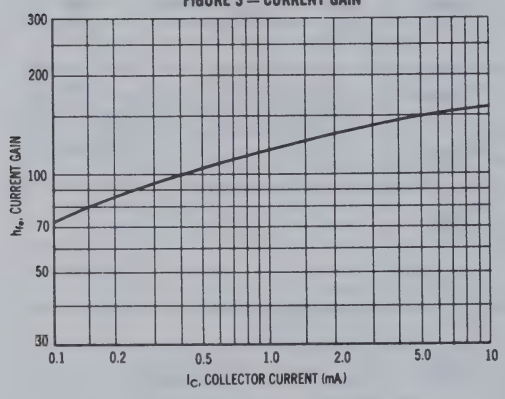


FIGURE 4 — OUTPUT ADMITTANCE

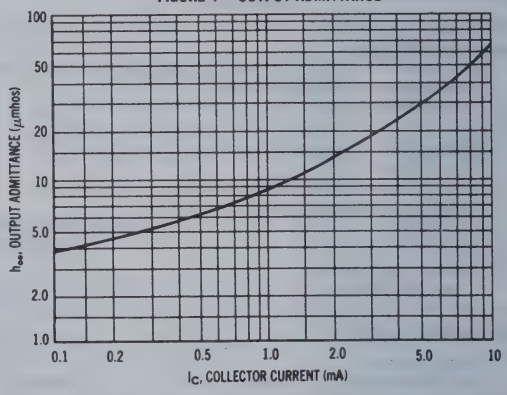


FIGURE 5 — INPUT IMPEDANCE

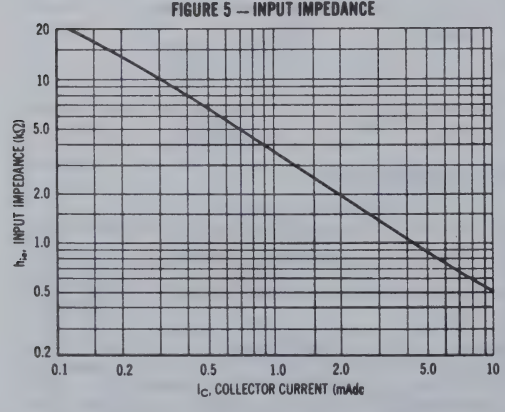
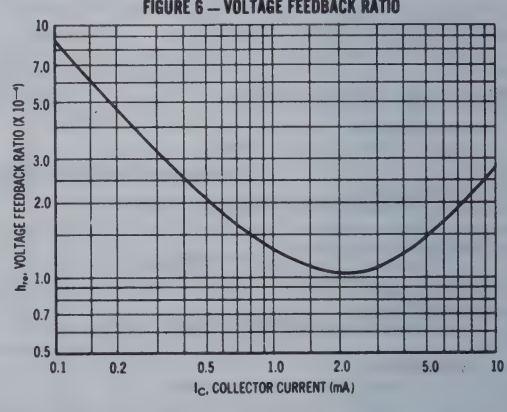


FIGURE 6 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 7 — NORMALIZED CURRENT GAIN

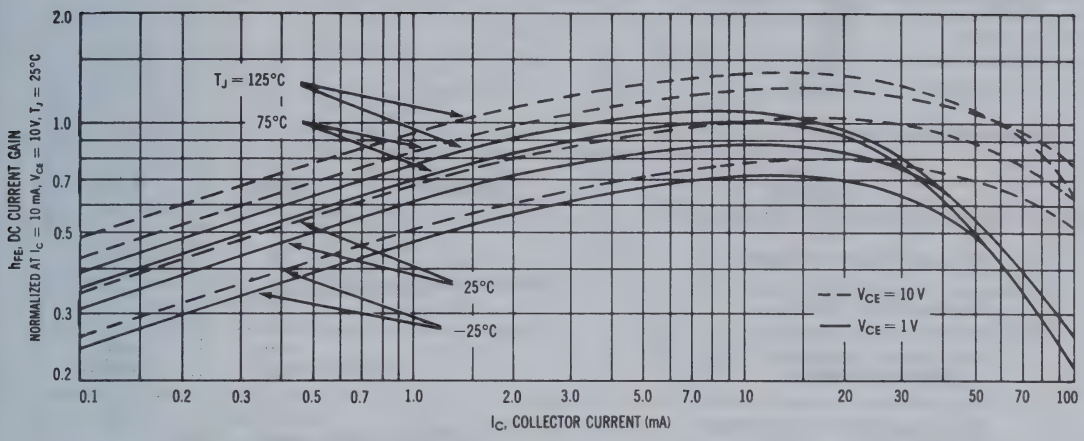


FIGURE 8 — COLLECTOR SATURATION REGION

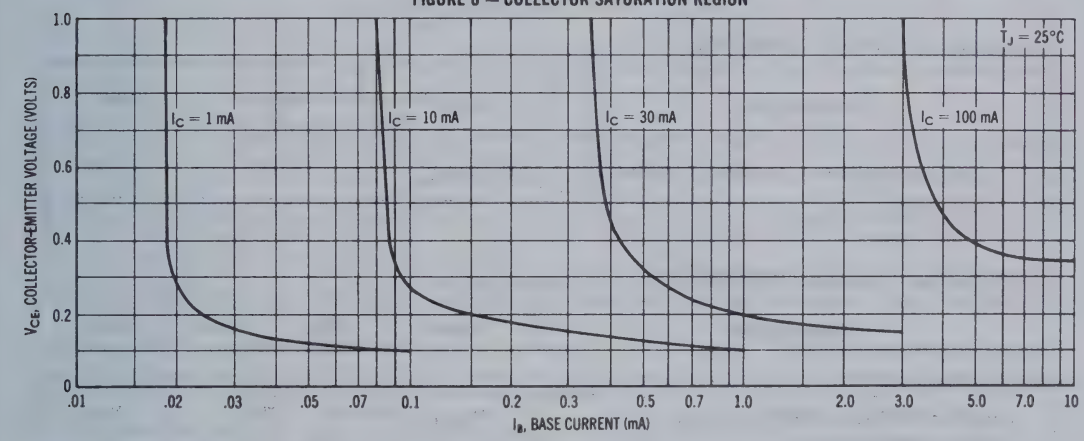


FIGURE 9 — TRANSCONDUCTANCE

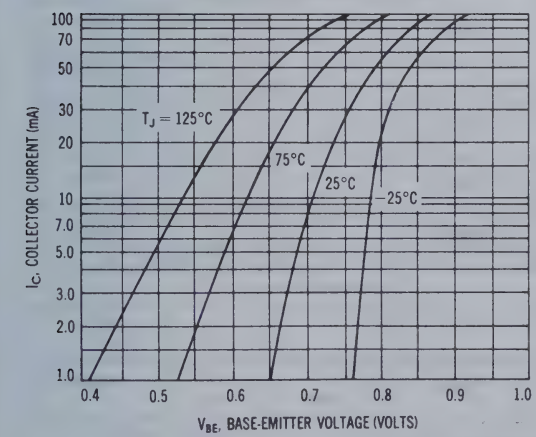
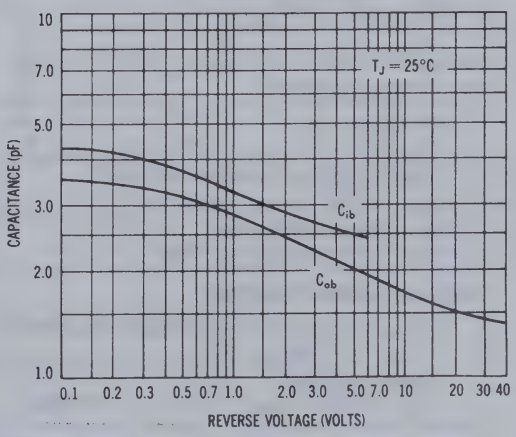


FIGURE 10 — CAPACITANCES



MPS6567 (SILICON)



CASE 29(2)
TO-92
Pin 1. Base
2. Emitter
3. Collector

NPN silicon annular transistor designed for 4.5 MHz sound IF applications in TV receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	—	0.8	Vdc
DYNAMIC CHARACTERISTICS				
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{re}	—	0.7	pF
Output Resistance (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 4.5 MHz)	R_{oep}	100	—	kohms

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

COMMON-EMITTER y PARAMETERS

$f = 4.5$ MHz, $T_A = 25°C$

FIGURE 1 — INPUT ADMITTANCE

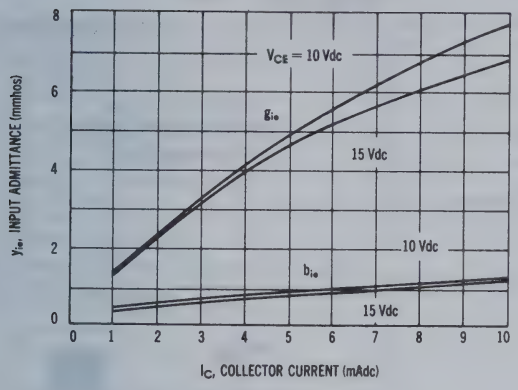


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

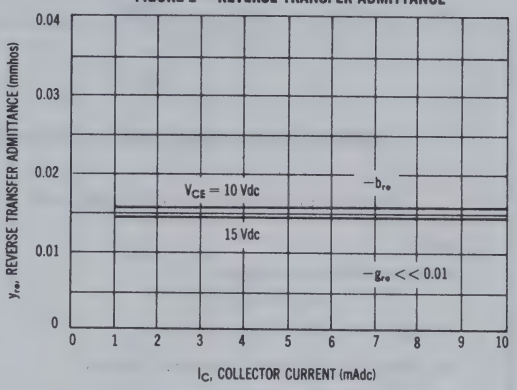


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

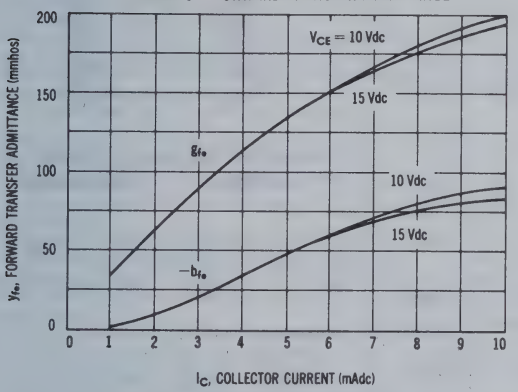


FIGURE 4 — OUTPUT ADMITTANCE

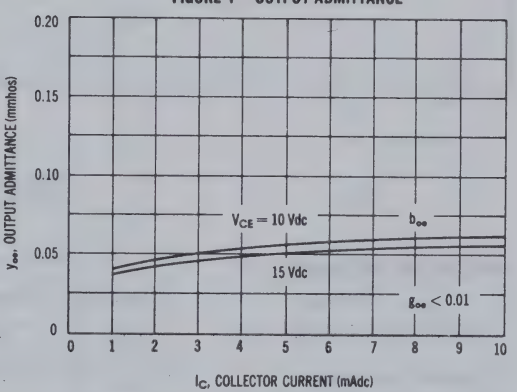


FIGURE 5 — CAPACITANCES

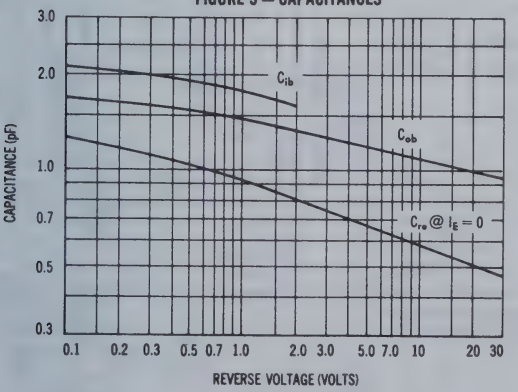
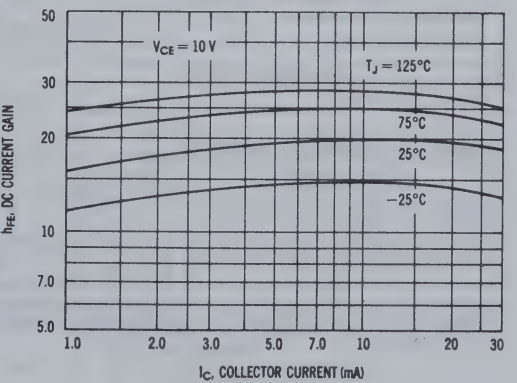


FIGURE 6 — DC CURRENT GAIN



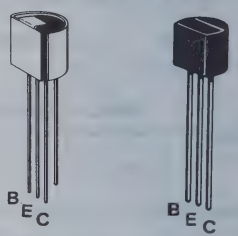
MPS6568 (SILICON)
MPS6568A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF-RF amplifier applications in TV receivers.

- Guaranteed Noise Figure –
  NF = 3.3 dB (Max) at 200 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves at 200 MHz
- Guaranteed Power Gain –
  G_{pe} = 20 dB (Min) at 200 MHz

NPN SILICON VHF RF AMPLIFIER TRANSISTORS



TO-92 WITH SHIELD MPS6568 | TO-92 MPS6568A

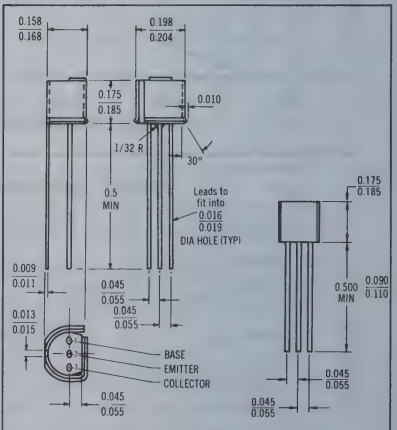
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

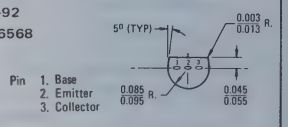
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	0.137	°C/mW
Thermal Resistance, Case to Ambient	θ_{CA}	0.220	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = –65 to +150°C, θ_{JC} = 125°C/W.



CASE 29A
TO-92
MPS6568



Pin 1. Base
2. Emitter
3. Collector

CASE 29 (2)
TO-92
MPS6568A

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 mAdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded, with shield) MPS6568 (without shield) MPS6568A	C_{cb}	0.25 -	0.5 0.65	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	NF	-	3.3	dB
FUNCTIONAL TEST				
Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	G_{pe}	20	27	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz, Figure 9)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9

FIGURE 1 — POWER GAIN

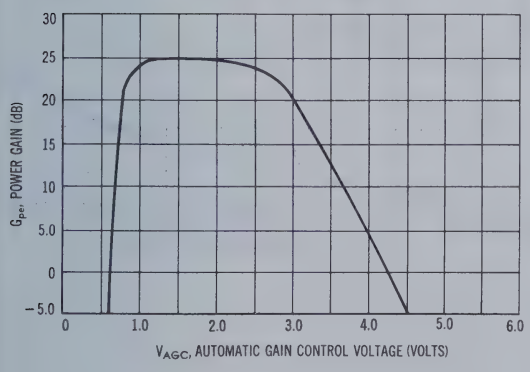
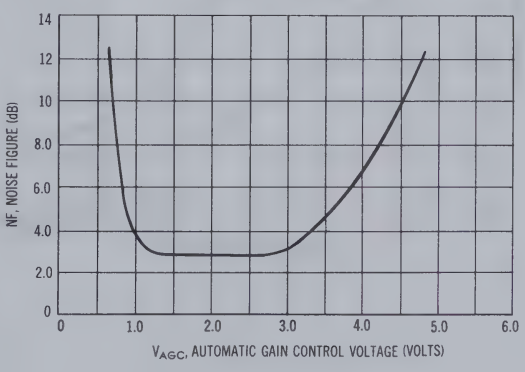


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C, f = 200 MHz

FIGURE 3 — INPUT ADMITTANCE

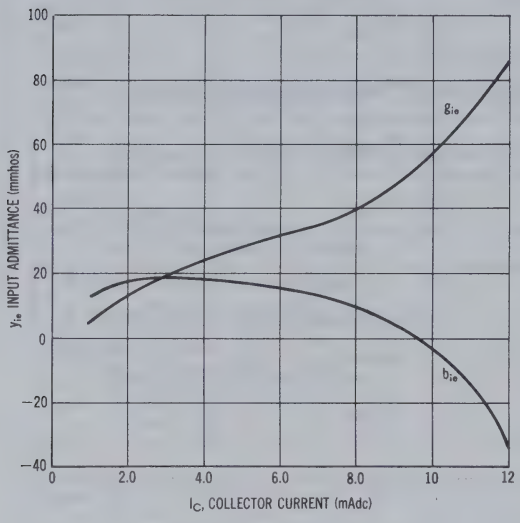


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

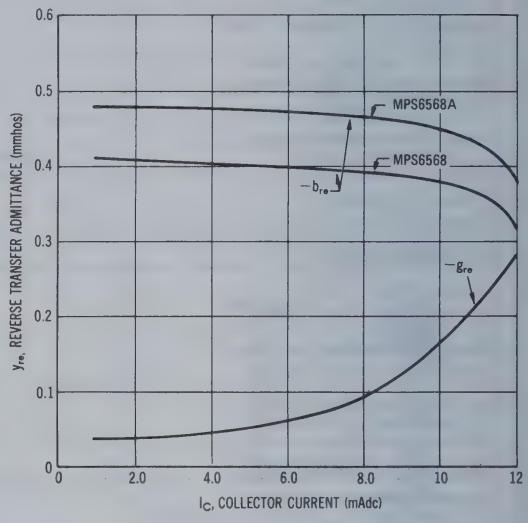


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

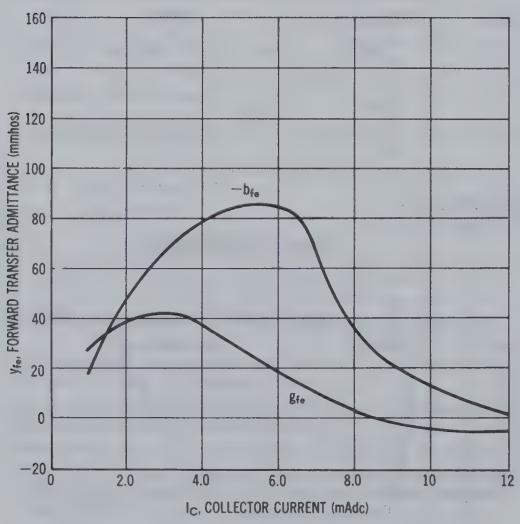


FIGURE 6 — OUTPUT ADMITTANCE

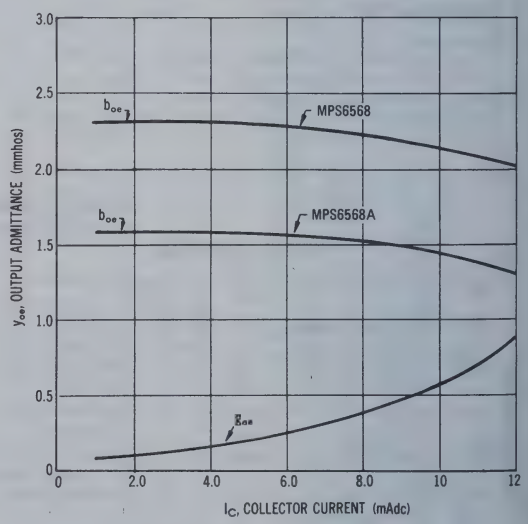


FIGURE 7 — DC CURRENT GAIN

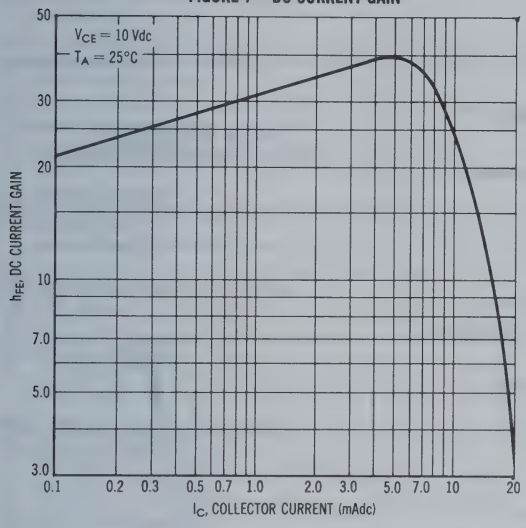


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

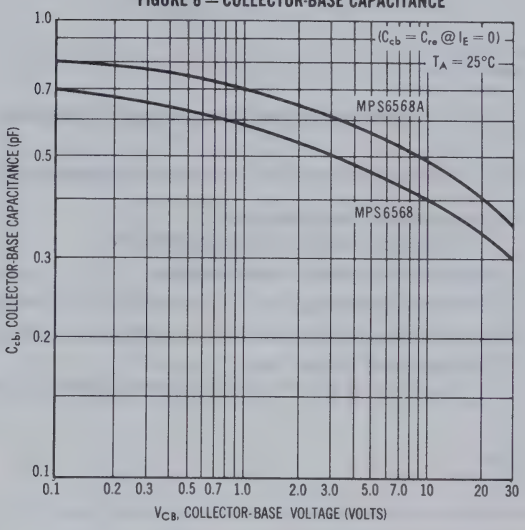
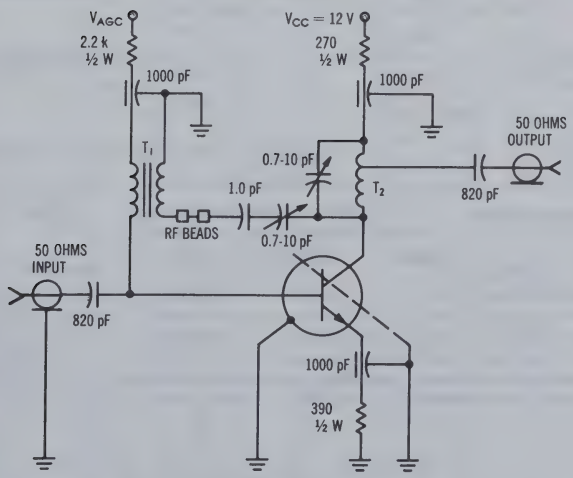


FIGURE 9 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾".

MPS6569 (SILICON)
MPS6570

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF-RF and video IF stages in TV receivers.

- Guaranteed Noise Figure
  NF = 6.0 dB maximum @ 45 MHZ
- Guaranteed AGC Characteristics
- External Shielding for Optimum RF Circuit Performance
- Complete y-Parameter Curves at Both 45 MHz and 200 MHz
- Guaranteed Power Gain
  G_{pe} = 22.5 dB minimum (Unneutralized) @ 45 MHz

NPN SILICON VHF TRANSISTORS



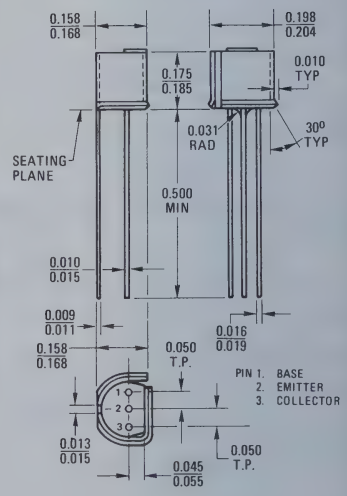
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	0.137	°C/mW
Thermal Resistance, Case to Ambient	θ_{CA}	0.220	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29A
PLASTIC TRANSISTOR
WITH SHIELD

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4 mAdc, V_{CE} = 5 Vdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz, emitter guarded, with shield)	C_{cb}	0.25	0.5	pF
Noise Figure (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10)	NF	-	6.0	dB
FUNCTIONAL TEST				
Power Gain (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10)	G_{pe}	22.5	28.5	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 10) MPS6569 MPS6570	V_{AGC}	4.4 5.2	5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10
f = 45 MHz

FIGURE 1 — POWER GAIN

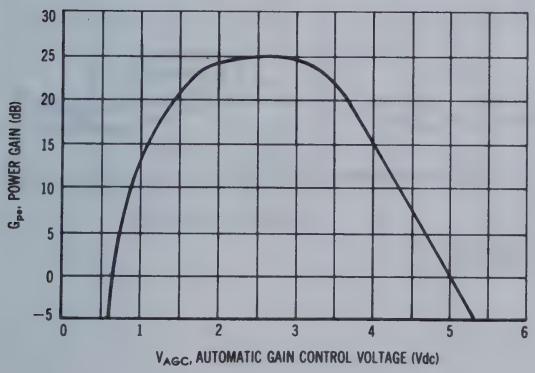
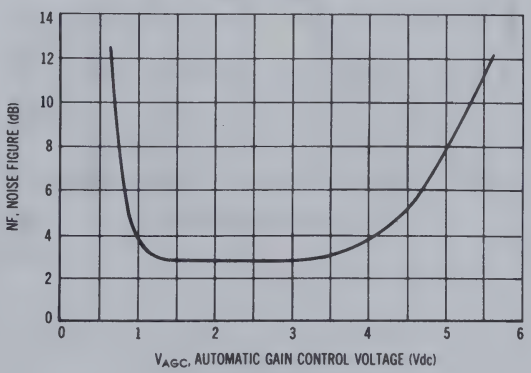


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C
f = 45 MHz

FIGURE 3 — INPUT ADMITTANCE

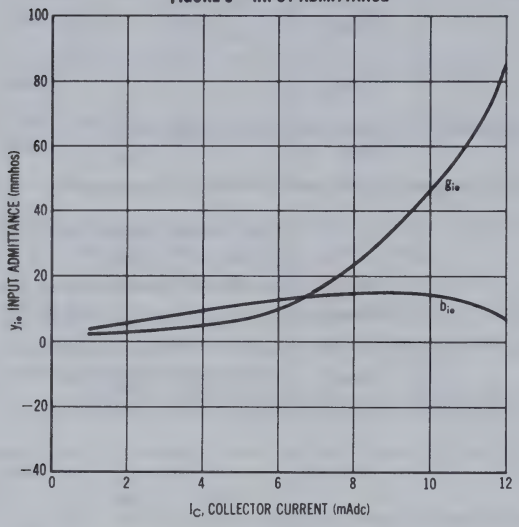


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

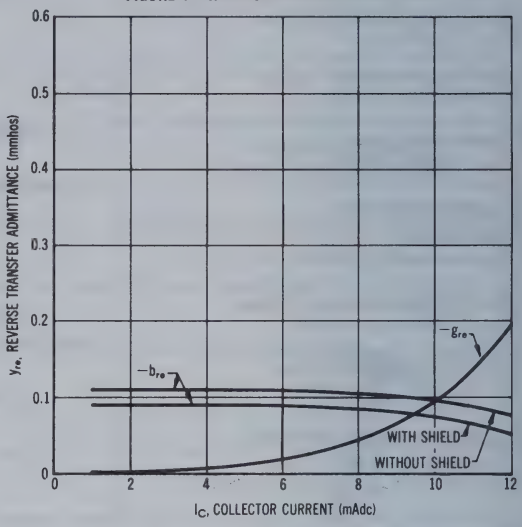


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

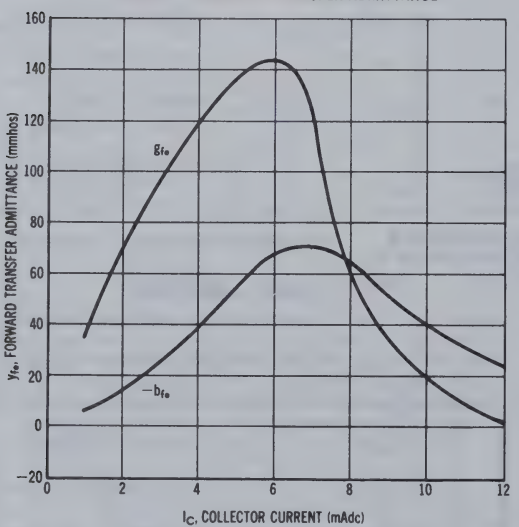


FIGURE 6 — OUTPUT ADMITTANCE

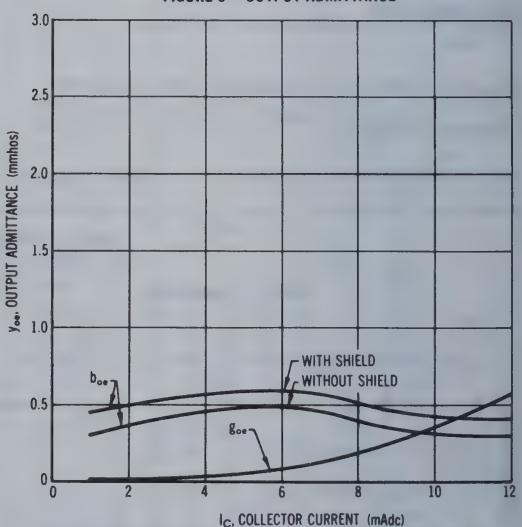


FIGURE 7 — DC CURRENT GAIN

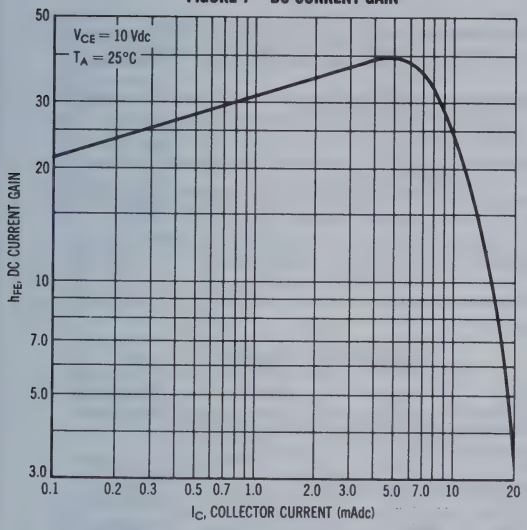


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

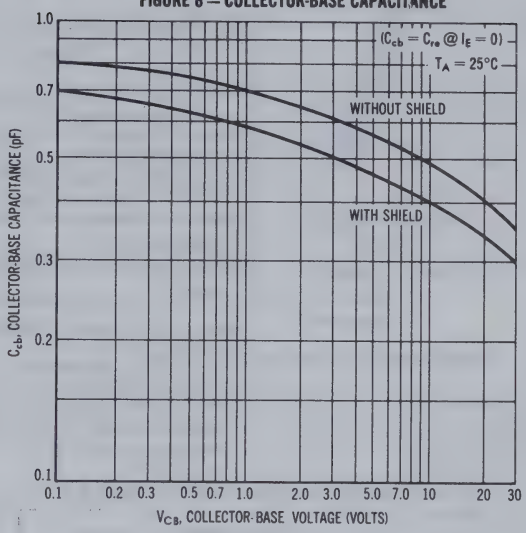
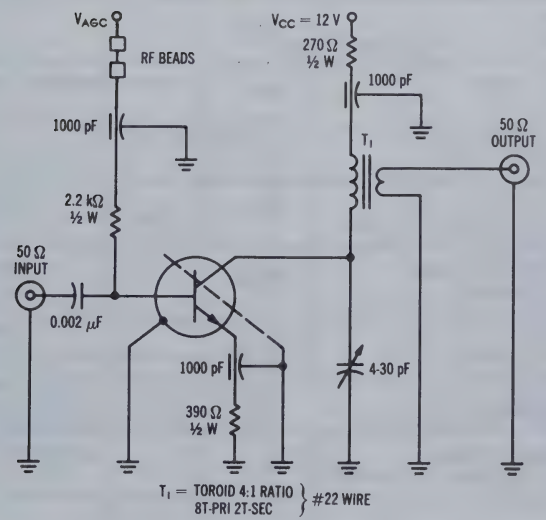


FIGURE 9 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MPS6571 (SILICON)



CASE 29(1)
TO-92

Pin 1. Emitter
2. Base
3. Collector

NPN silicon annular amplifier transistor designed for audio pre-amplifier applications in audio amplifiers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	20	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BV_{CBO}	25	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	250	-	1000	-
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On, Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	-	-	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	50	175	-	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	-	4.5	pF
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_s = 10$ kohms, f = 100 Hz)	NF	-	1.2	-	dB

FIGURE 1 — DC CURRENT GAIN

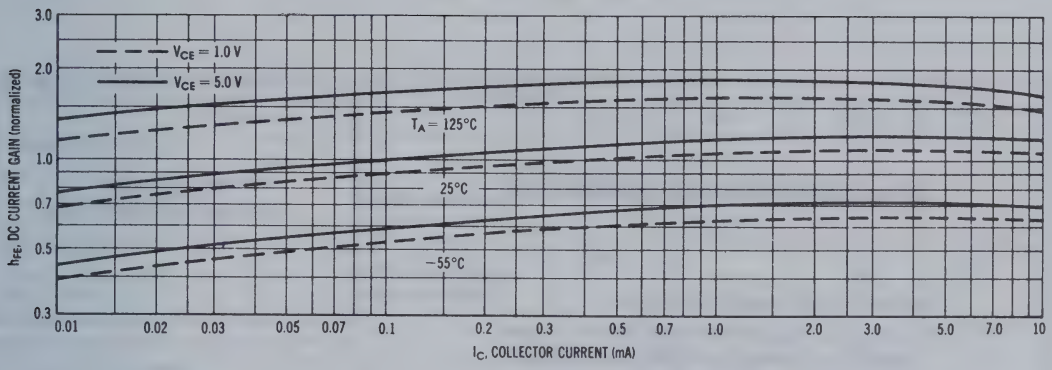


FIGURE 2 — CURRENT GAIN

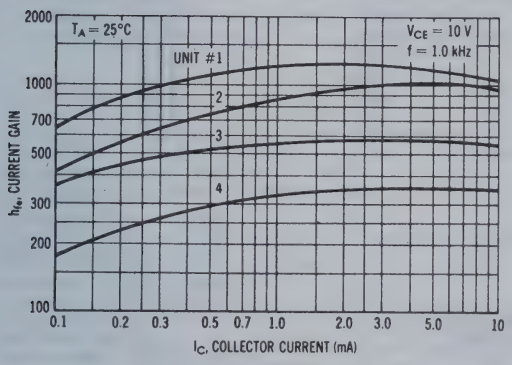
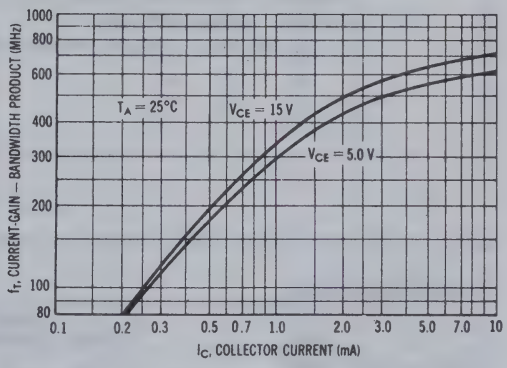


FIGURE 3 — CURRENT GAIN — BANDWIDTH PRODUCT



NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 4 — FREQUENCY EFFECTS

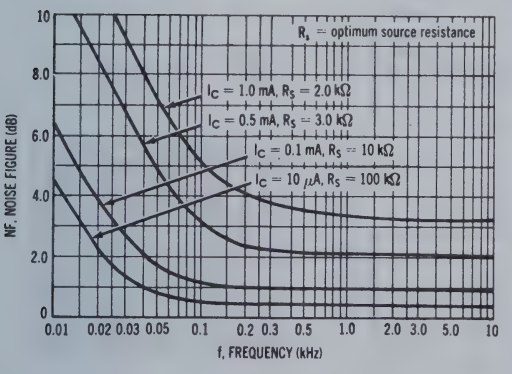
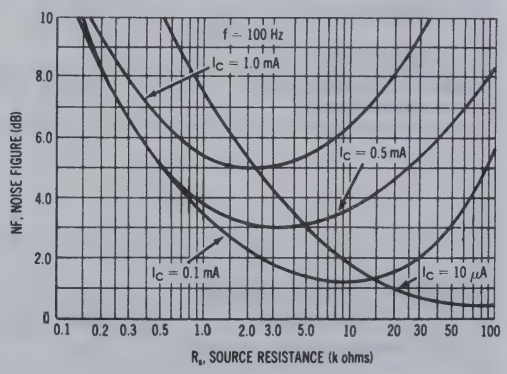


FIGURE 5 — SOURCE RESISTANCE EFFECTS



MPS6573 (SILICON)
thru
MPS6576

NPN SILICON ANNULAR TRANSISTORS

. . . designed for audio amplifier applications.

- DC Current Gain Specified for Audio Predriver Design — 100 μAdc to 10 mAdc for MPS6573 and MPS6575
- DC Current Gain to Facilitate Differential Amplifier Design for Audio Input Stages — Grouping at 1.0 mAdc for MPS6574 and MPS6576
- Current-Gain — Bandwidth Product — f_T = 200 MHz (Max) for Audio Frequency Design

NPN SILICON AUDIO TRANSISTORS

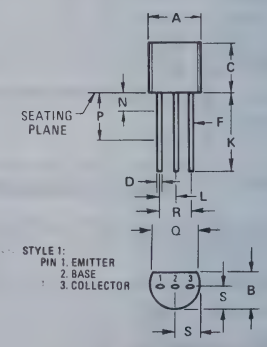


MAXIMUM RATINGS

Rating	Symbol	MPS6573 MPS6574	MPS6575 MPS6576	Unit
Collector-Emitter Voltage	V_{CEO}	35	45	Vdc
Collector-Base Voltage	V_{CB}	35	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C @ T_A = 60°C Derate above 25°C	P_D	310 210 2.73		mW mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS6573,MPS6574 MPS6575,MPS6576	BV_{CEO}	 35 45	 – –	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0)	 MPS6573,MPS6574 MPS6575,MPS6576	I_{CBO}	 – –	 100 100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	 MPS6573,MPS6575 MPS6573,MPS6575 MPS6574,MPS6576(1) Yellow Blue Green Silver	h_{FE}	 100 200 100 125 150 200	 – 500 150 185 225 300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		f_T	–	200	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	12	pF

(1) The MPS6574 and MPS6576 will be color coded to identify DC Current Gain Categories.

MPS6590 (SILICON)
MPS6591

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose, low-level amplifier applications.

- High Breakdown Voltage — BV_{CEO} = 80 Vdc (Min) MPS6590
- One-Piece, Injection-Molded Unibloc Package

NPN SILICON AMPLIFIER TRANSISTORS

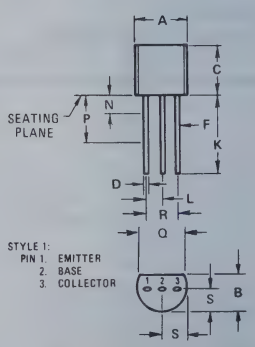


MAXIMUM RATINGS

Rating	Symbol	MPS6590	MPS6591	Unit
Collector-Emitter Voltage	V_{CEO}	80	50	Vdc
Collector-Base Voltage	V_{CB}	100	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current - Continuous	I_C	250		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0) MPS6590	BV_{CEO}	80	-	-	Vdc
MPS6591		50	-	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) MPS6590	BV_{CBO}	100	-	-	Vdc
MPS6591		60	-	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) MPS6590	I_{CBO}	-	-	100	nAdc
(V_{CB} = 30 Vdc, I_E = 0) MPS6591		-	-	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	-	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.6	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	-	12	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	-	50	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	-	1.4	-	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	-	0.8	-	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	h_{fe}	2.0	-	-	-
Output Admittance (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	-	75	-	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 4.0 k ohms, f = 10 Hz to 15.7 kHz)	NF	-	3.0	-	dB

MPS8000 (SILICON)

NPN SILICON ANNULAR RF TRANSISTOR

. . . designed for use in Citizen-Band Communications equipment operating to 30 MHz. High current gain available for driver applications. This device is designed to be used with the MPS8001 RF oscillator and the MPS-U31 RF power output.

350 mW – 27 MHz

RF DRIVER TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

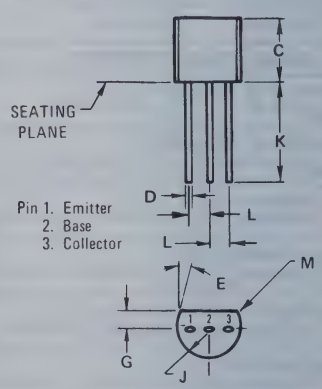
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.5	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{CA}$	200	$^oC/W$

(1) Typical printed circuit board mounting.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	30	–	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (P_{out} = 350 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	G_{pe}	12	–	dB
Power Output (P_{in} = 21.8 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	P_{out}	350	–	mW



	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	5^o NOM		5^o NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330

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TYPICAL CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

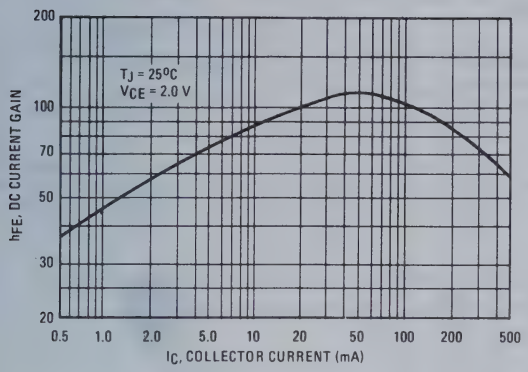


FIGURE 2 – ON VOLTAGES

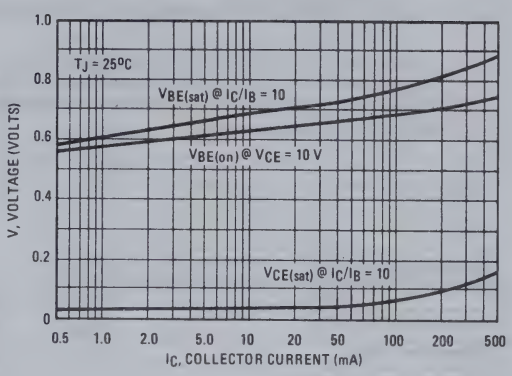


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

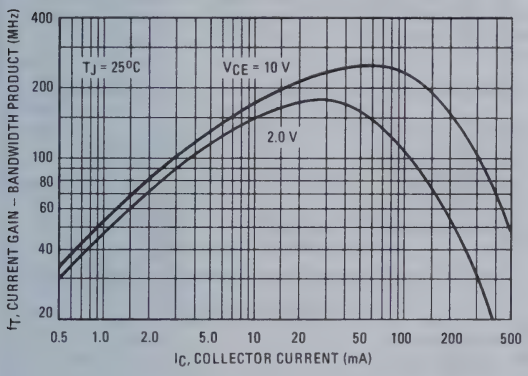


FIGURE 4 – CAPACITANCE

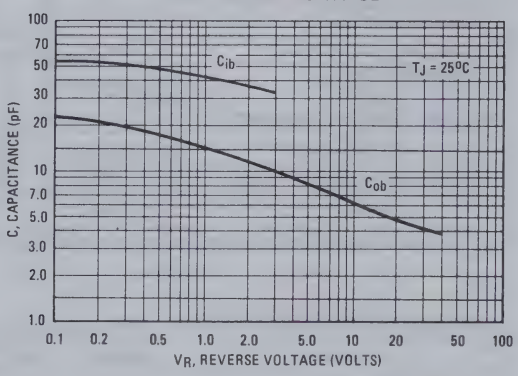
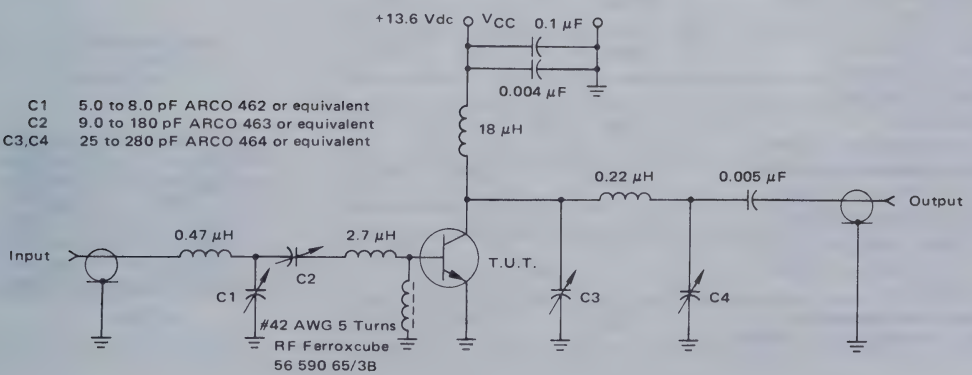


FIGURE 5 – 27 MHz TEST CIRCUIT



MPS8001 (SILICON)

NPN SILICON RF ANNULAR TRANSISTOR

. . . designed for use in Citizen-Band communications equipment operating to 30 MHz, with low feedback capacity for stable operation. This part is designed to be used with the MPS8000 driver and the MPS-U31 RF power output.

RF OSCILLATOR
TRANSISTOR
NPN SILICON



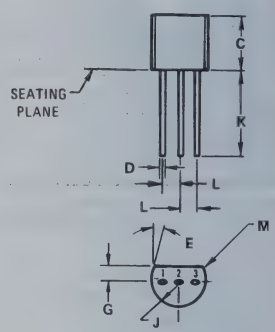
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/mW$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$*	357	$^oC/mW$

*$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	5^o NOM		5^o NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330

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ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	–	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ce}	–	0.65	pF

FIGURE 1 – DC CURRENT GAIN

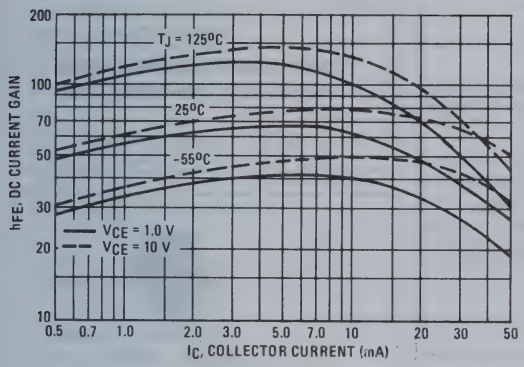


FIGURE 2 – "ON" VOLTAGE

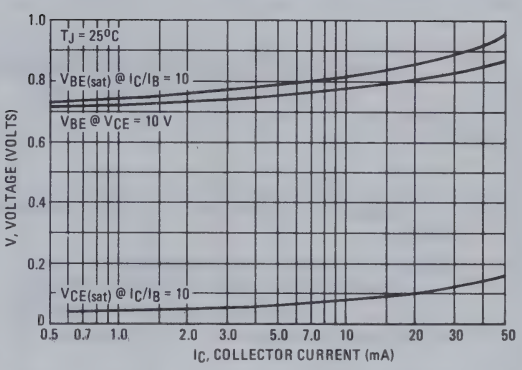


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

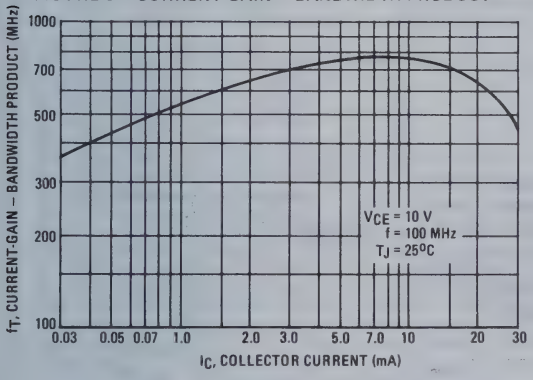
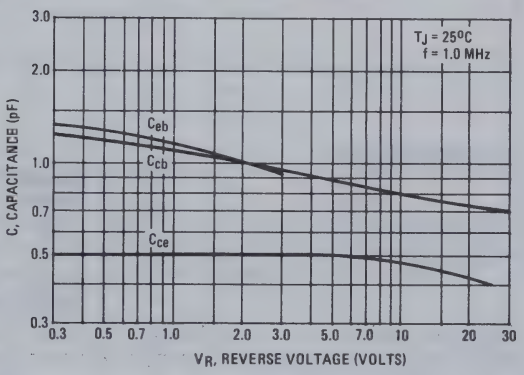


FIGURE 4 – CAPACITANCE



MPS8098, MPS8099 NPN (SILICON)
MPS8598, MPS8599 PNP

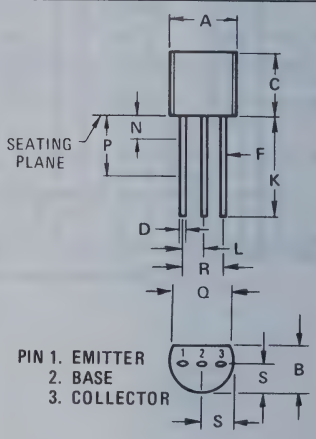
COMPLEMENTARY SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose amplifier applications for audio circuits.

- Collector Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) – MPS8098, MPS8598
  80 Vdc (Min) – MPS8099, MPS8599
- DC Current Gain Specified – 1.0 to 100 mAdc

COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

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MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
		MPS8098 MPS8099	MPS8598 MPS8599	
Emitter-Base Voltage	V_{EB}	6.0	5.0	Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

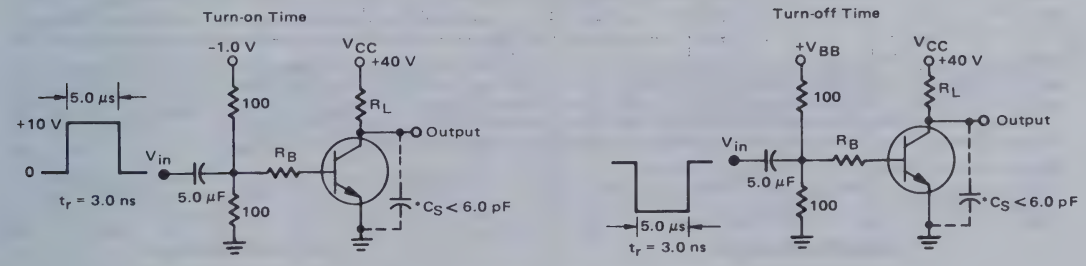
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted).

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MPS8098,MPS8598	BV_{CEO}	60	–	Vdc
	MPS8099,MPS8599		80	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS8098 MPS8598	BV_{CBO}	60	–	Vdc
	MPS8099,MPS8599		80	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS8098,MPS8099	BV_{EBO}	6.0	–	Vdc
	MPS8598,MPS8599		5.0	–	
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MPS8098,MPS8598	I_{CBO}	–	0.1	μAdc
(V_{CB} = 80 Vdc, I_E = 0)	MPS8099,MPS8599		–	0.1	
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	MPS8098,MPS8099	I_{EBO}	–	0.1	μAdc
(V_{EB} = 5.0 Vdc, I_C = 0)	MPS8598,MPS8599		–	0.1	
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	100	300	–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			100	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)			75	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	0.4	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.3	
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPS8098,MPS8598	$V_{BE(on)}$	0.5	0.7	Vdc
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS8099,MPS8599		0.6	0.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	150	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS8098,MPS8099	C_{ob}	–	6.0	pF
	MPS8598,MPS8599		–	8.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS8098,MPS8099	C_{ib}	–	25	pF
	MPS8598,MPS8599		–	30	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS

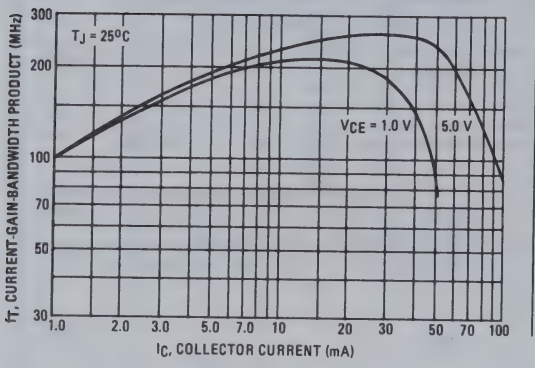


*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN
MPS8098,MPS8099

PNP
MPS8598,MPS8599

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT



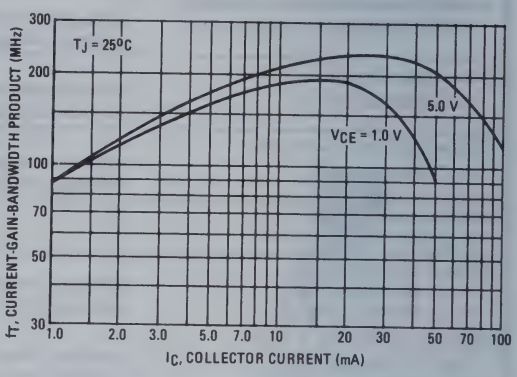
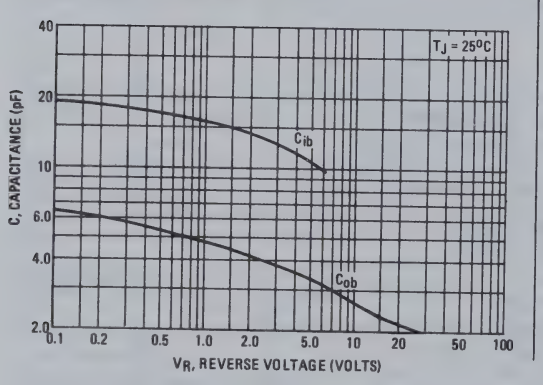


FIGURE 3 – CAPACITANCE



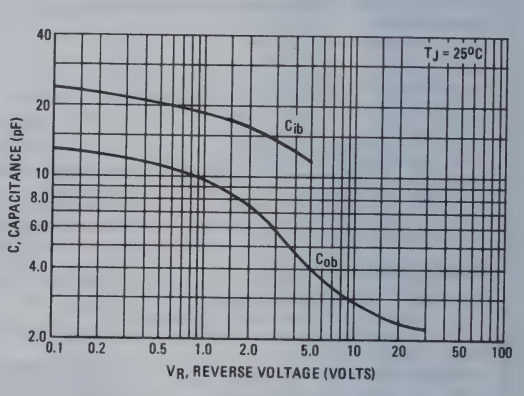
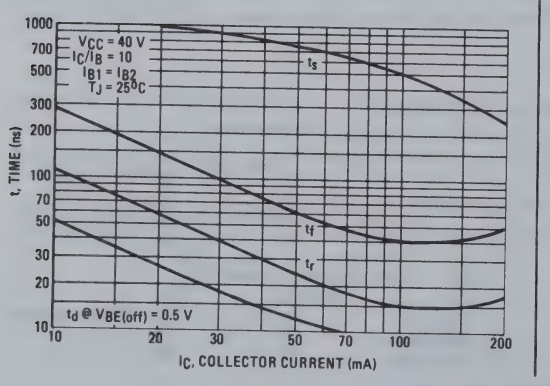


FIGURE 4 – SWITCHING TIMES



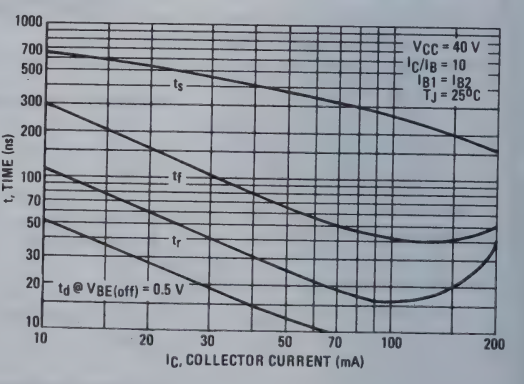


FIGURE 5 – THERMAL RESPONSE

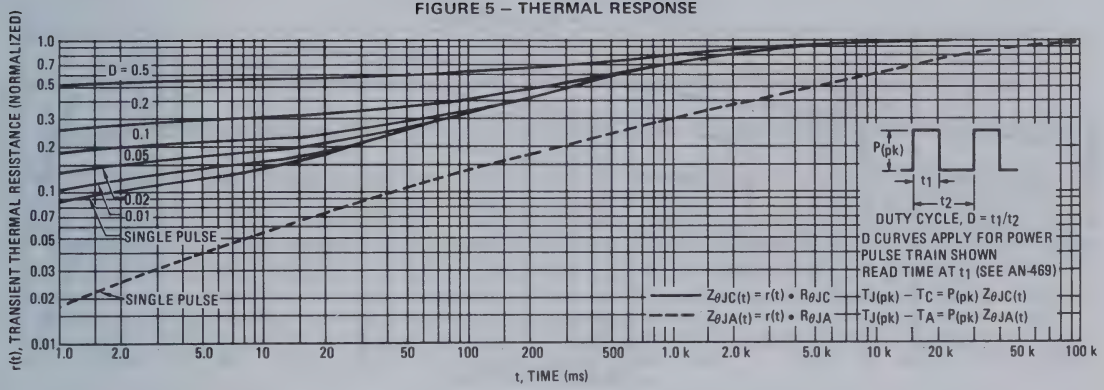
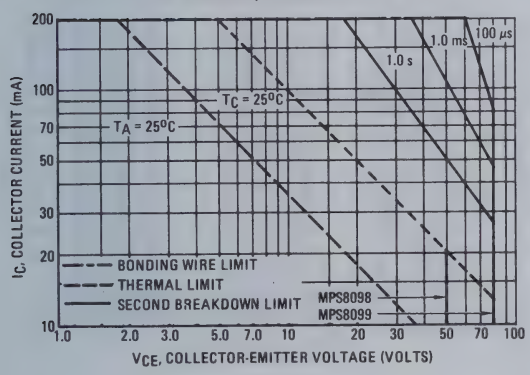
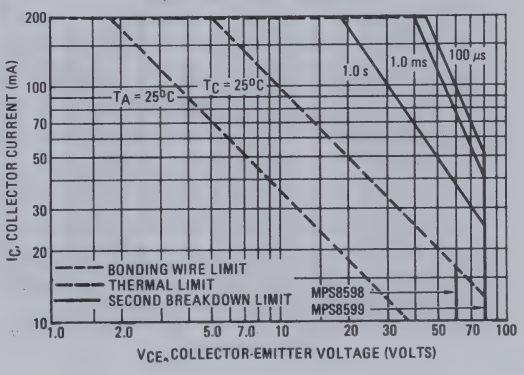


FIGURE 6 – ACTIVE-REGION SAFE OPERATING AREA

MPS8098, MPS8099



MPS8598, MPS8599



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)} = 150^oC$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 5. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown. (See AN-415)

NPN
MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN

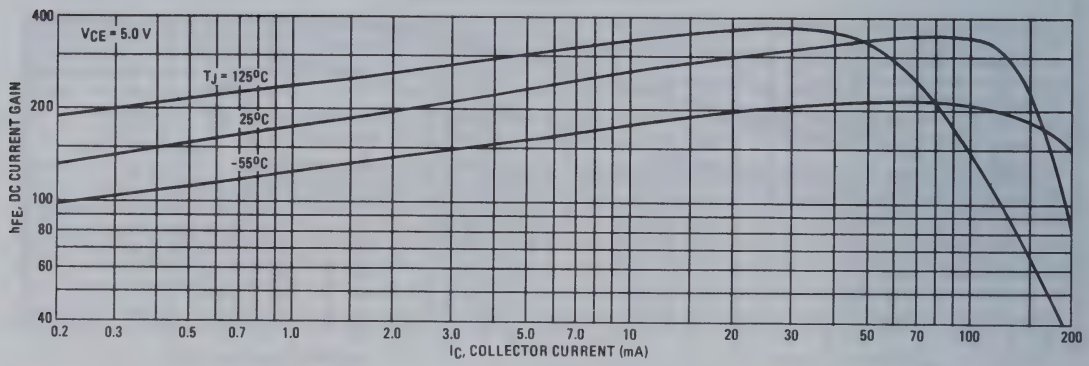


FIGURE 8 – "ON" VOLTAGES

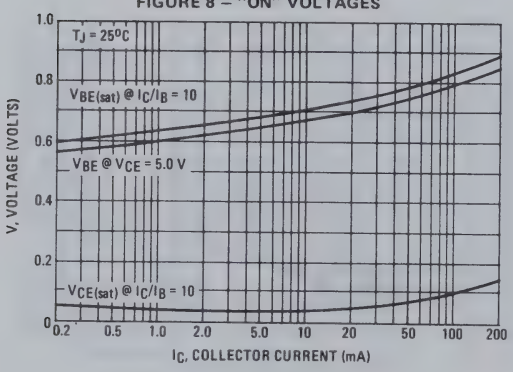


FIGURE 9 – COLLECTOR SATURATION REGION

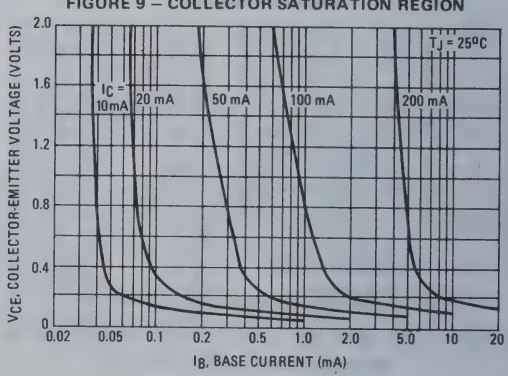
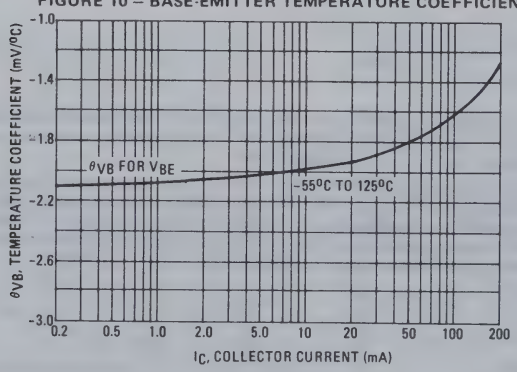


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPS8598, MPS8599

FIGURE 11 – DC CURRENT GAIN

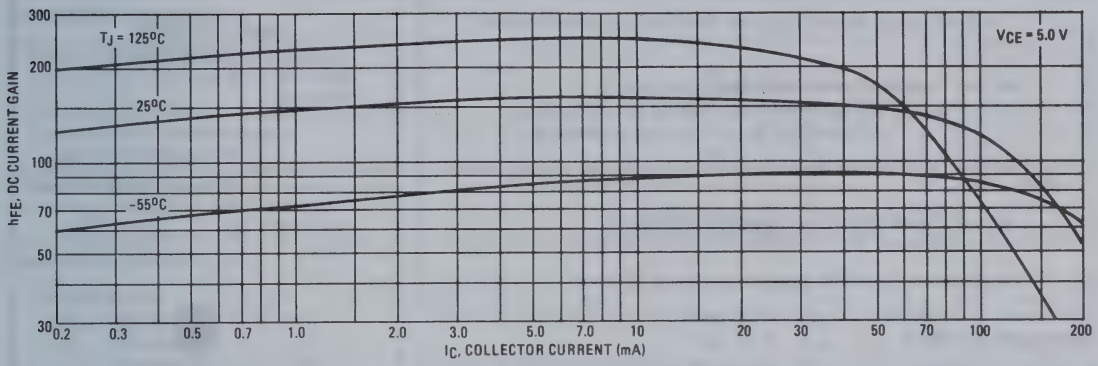


FIGURE 12 – "ON" VOLTAGES

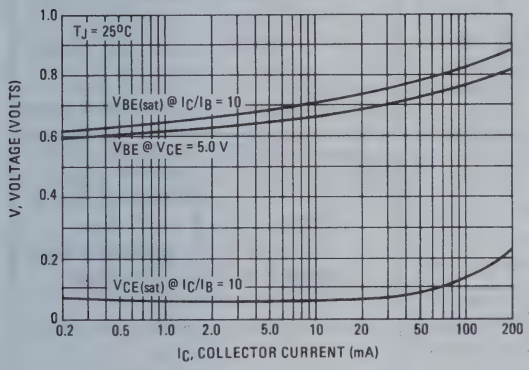


FIGURE 13 – COLLECTOR SATURATION REGION

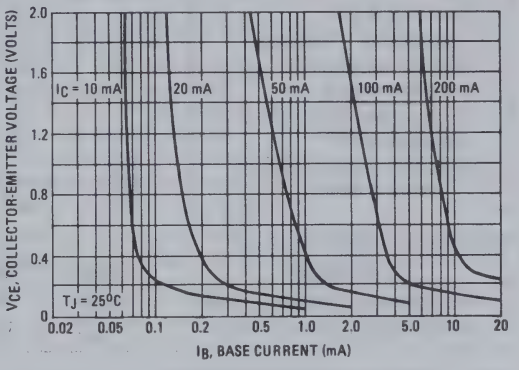
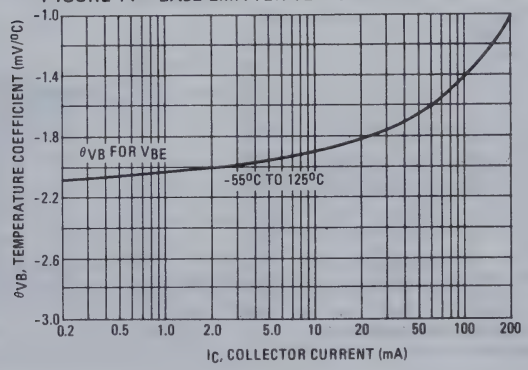


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPS-A05 (SILICON)
MPS-A06

NPN SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for use as medium-power driver and low-power outputs.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-A05
  = 80 Vdc (Min) @I_C = 1.0 mAdc – MPS-A06
- Excellent Current-Gain Linearity – 1.0 mAdc to 200 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @I_C = 100 mAdc
- Complements to PNP types MPS-A55 and MPS-A56

NPN SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

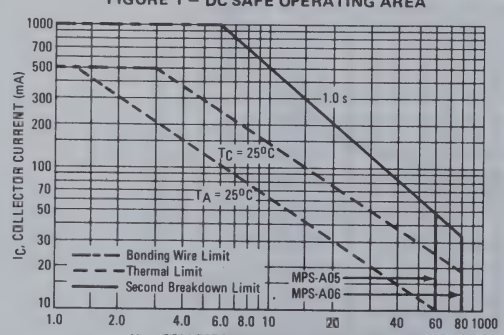
Rating	Symbol	MPS-A05	MPS-A06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

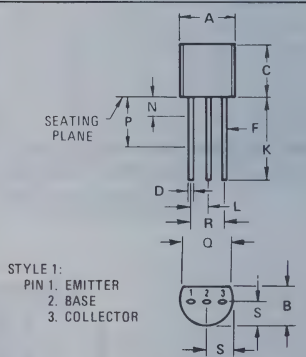
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	oC/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

FIGURE 1 – DC SAFE OPERATING AREA





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless othewise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1)	BV_{CEO}				Vdc
(I_C = 1.0 mAdc, I_B = 0) MPS-A05		60	–	–	
MPS-A06		80	–	–	
Emitter-Base Breakdown Voltage	BV_{EBO}				Vdc
(I_E = 100 μAdc, I_C = 0)		4.0	–	–	
Collector Cutoff Current	I_{CBO}				nAdc
(V_{CB} = 60 Vdc, I_E = 0) MPS-A05		–	–	100	
(V_{CB} = 80 Vdc, I_E = 0) MPS-A06		–	–	100	
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		50	90	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	105	–	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)		–	70	–	
Collector–Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.06	0.25	
Base–Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.78	–	
Base–Emitter On Voltage	$V_{BE(on)}$				Vdc
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		–	0.79	1.2	
SMALL-SIGNAL CHARACTERISTICS					
Current–Gain – Bandwidth Product	f_T				MHz
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)		50	150	–	
Output Capacitance	C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		–	6.0	–	
Input Capacitance	C_{ib}				pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		–	15	–	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ON VOLTAGES

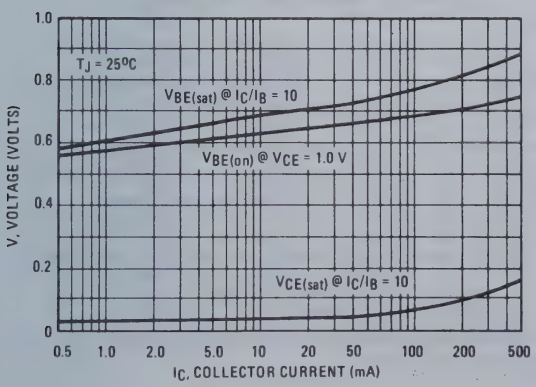
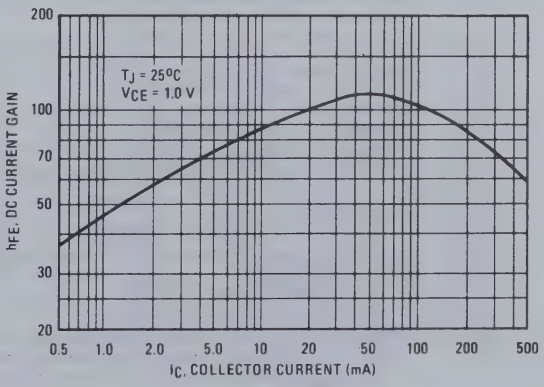


FIGURE 3 – DC CURRENT GAIN



MPS-A09 (SILICON)



NPN silicon annular amplifier transistors designed for pre-amplifier applications in audio amplifiers.

CASE 29(1)
(TO-92)

Pin 1. Emitter
2. Base
3. Collector

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Collector Current - Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	100	-	600	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.9	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 0.5 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	80	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	5.0	pF
Noise Figure (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc, R_S = 6.8 k ohms, f = 1.0 kHz)	NF	-	1.4	-	dB

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 – DC CURRENT GAIN

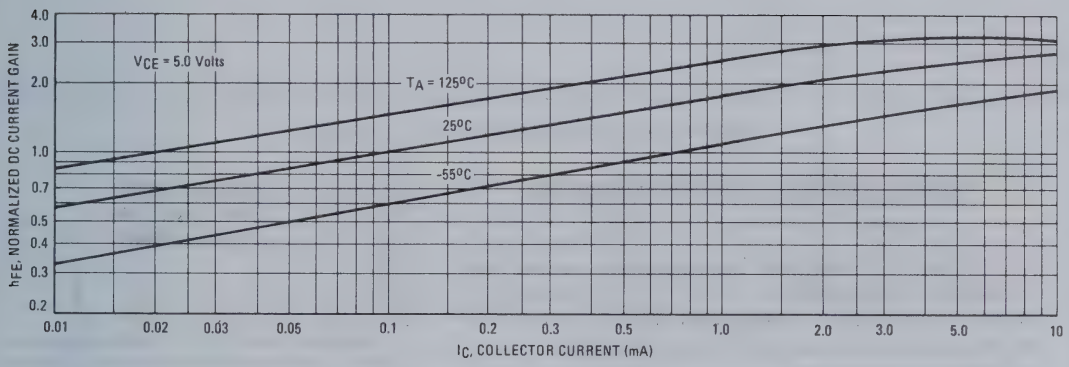


FIGURE 2 – COLLECTOR SATURATION REGION

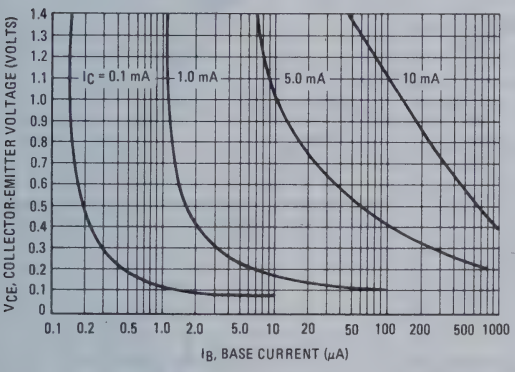
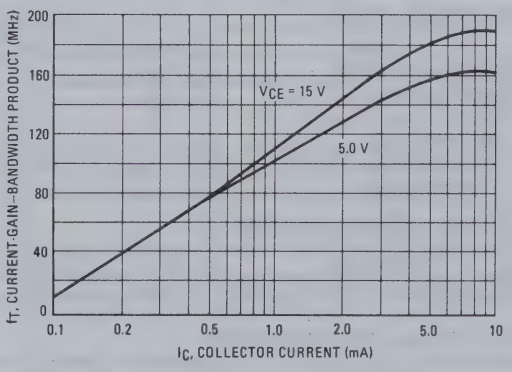


FIGURE 3 – CURRENT GAIN–BANDWIDTH PRODUCT



NOISE FIGURE

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

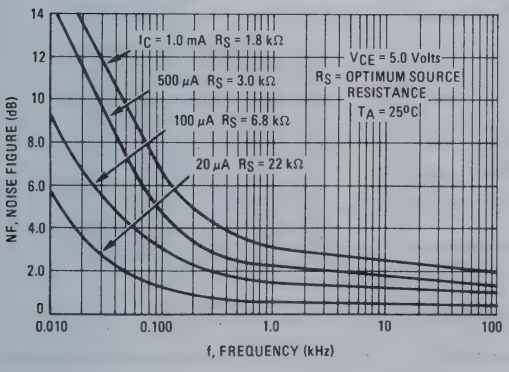
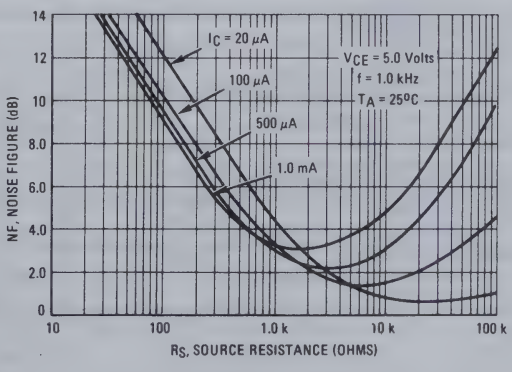


FIGURE 5 - SOURCE RESISTANCE EFFECT



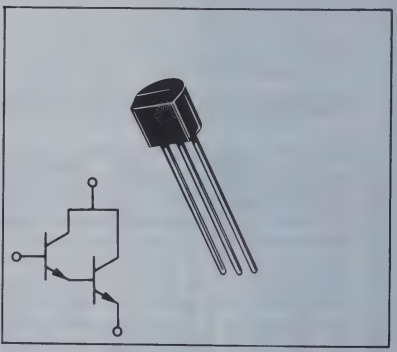
MPS-A12 (SILICON)

NPN SILICON DARLINGTON TRANSISTOR

. . . designed for pre-amplifier input applications requiring input impedance of several megohms.

- Excellent Current-Gain Linearity from 1.0 mA to 100 mA
- Features Extremely High Current Gain – 20,000 (Min)
- Monolithic Construction

NPN SILICON DARLINGTON TRANSISTOR



MAXIMUM RATINGS

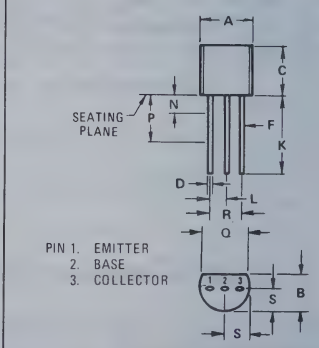
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	BV_{CES}	20	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20,000	–	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.01 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	–	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	C_{ob}	–	8.0	–	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	–	35	–	–



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.175	0.205	4.450	5.200
B	0.125	0.165	3.180	4.190
C	0.170	0.210	4.320	5.330
D	0.016	0.021	0.407	0.533
F	0.016	0.019	0.407	0.482
K	0.500	–	12.700	–
L	0.045	0.055	1.150	1.390
N	–	0.050	–	1.270
P	0.250	–	6.350	–
Q	0.135	–	3.430	–
R	0.095	0.105	2.410	2.670
S	0.080	0.105	2.030	2.670

CASE 29-02
(TO-92)

FIGURE 1 – NORMALIZED DC CURRENT GAIN

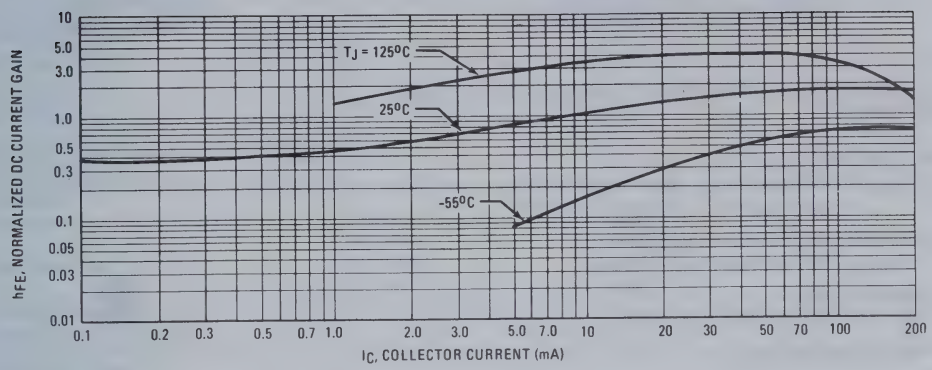


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE

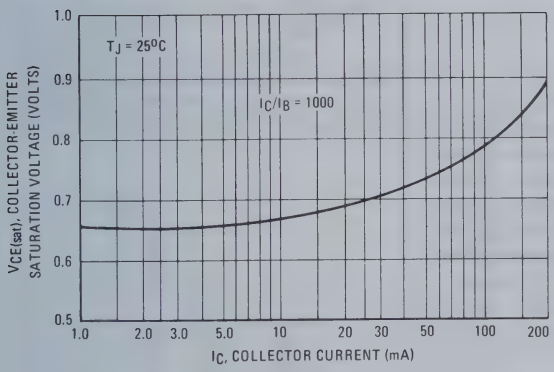


FIGURE 3 – BASE EMITTER "ON" VOLTAGE

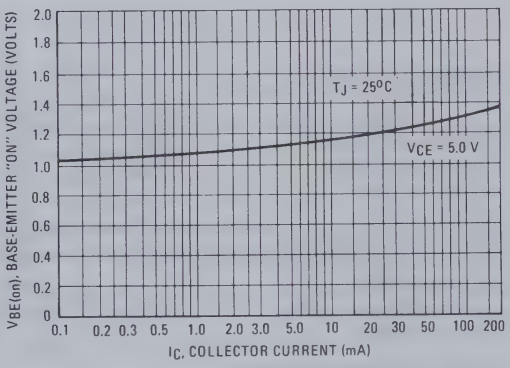
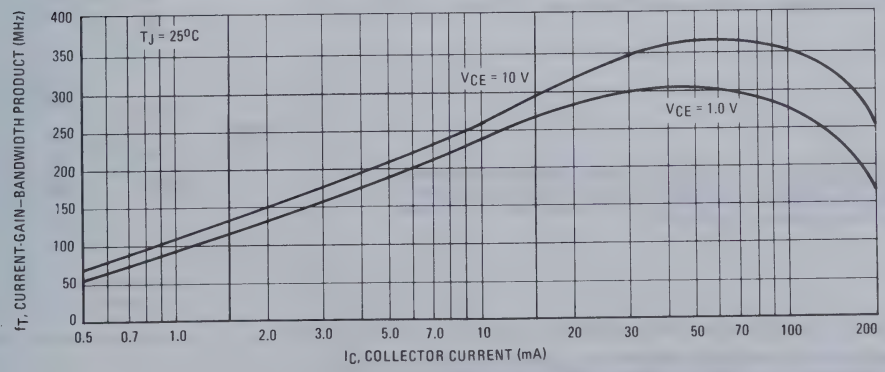


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



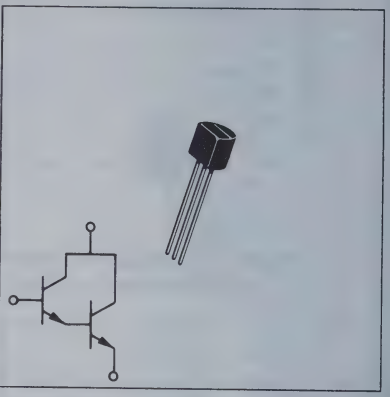
MPS-A13 (SILICON)
MPS-A14

NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain –
  h_{FE} = 5,000 (Min) @ I_C = 10 mAdc (MPS-A13)
  10,000 (Min) @ I_C = 10 mAdc (MPS-A14)
- Collector-Emitter Breakdown Voltage –
  BV_{CES} = 30 Vdc (Min) @ I_C = 10 mAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc
- Monolithic Construction

NPN SILICON DARLINGTON TRANSISTORS



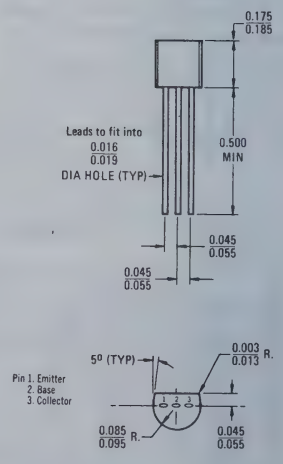
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}*	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current – Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.220	°C/mW

*Due to the monolithic construction of this device, breakdown voltages of both transistors are identical. BV_{CES} is tested in lieu of BV_{CEO} in order to avoid errors caused by noise pickup. The voltage measured during the BV_{CES} test is the BV_{CEO} of the output transistor.



CASE 29 (1)
TO-92

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)		BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS-A13		5000	–	–	
	MPS-A14		10,000	--	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPS-A13		10,000	–	–	
	MPS-A14		20,000	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.8	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.25	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	5.0	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)		NF	–	2.0	–	dB

FIGURE 1 – NORMALIZED DC CURRENT GAIN

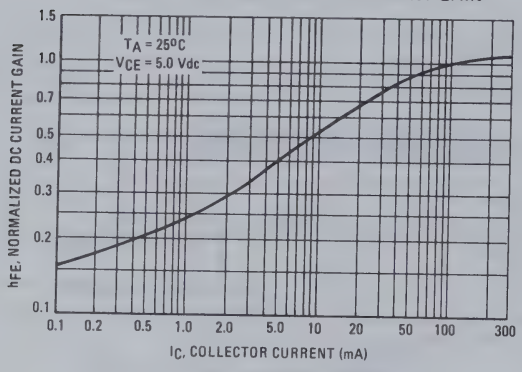


FIGURE 2 – BASE-EMITTER "ON" VOLTAGE

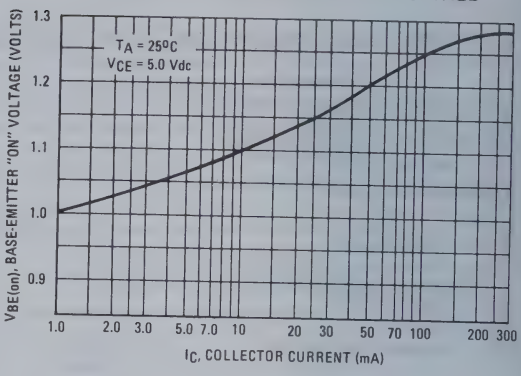


FIGURE 3 – TRANSCONDUCTANCE versus FREQUENCY

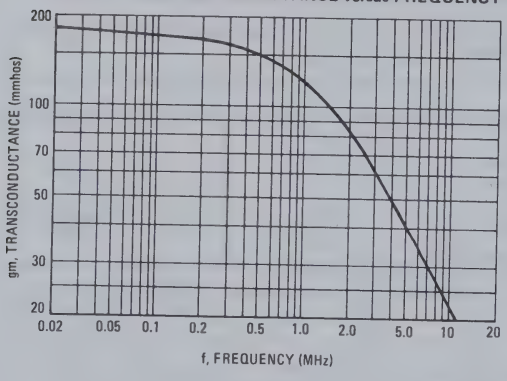


FIGURE 4 – NOISE FIGURE versus CURRENT

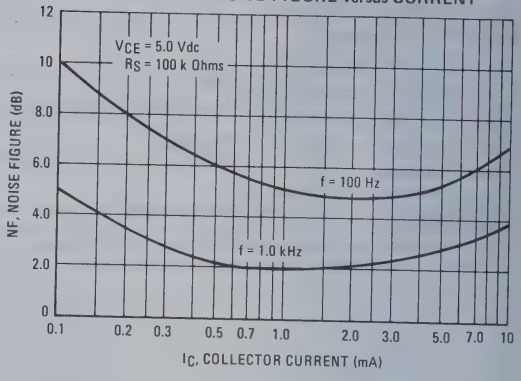


FIGURE 5 – NOISE FIGURE versus FREQUENCY

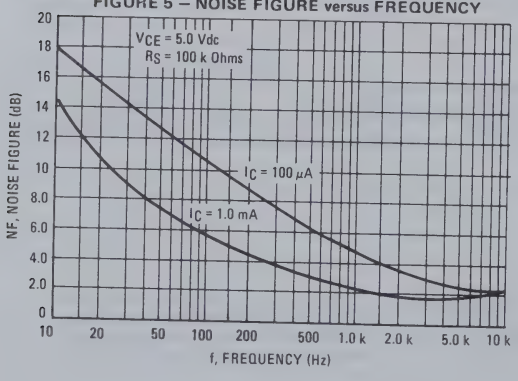
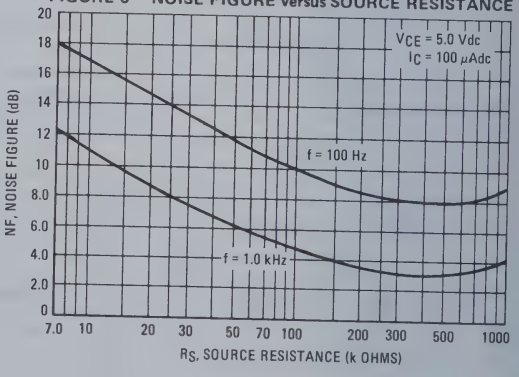


FIGURE 6 – NOISE FIGURE versus SOURCE RESISTANCE



MPS-A16 (SILICON)
MPS-A17

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in moderate speed switching and clipping applications that require large input voltage capability.

- High-Emitter-Base Breakdown Voltage –
  BV_{EBO} = 12 Vdc (Min) @ I_E = 0.1 mAdc – MPS-A16
  = 15 Vdc (Min) @ I_E = 0.1 mAdc – MPS-A17

NPN SILICON CHOPPER TRANSISTORS



MAXIMUM RATINGS

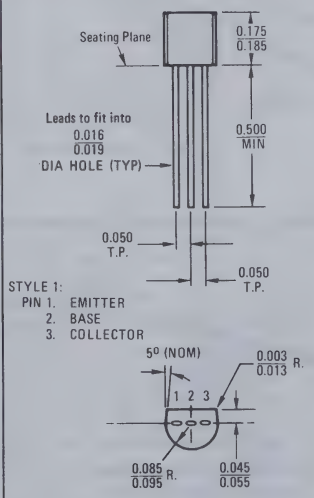
Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	12	15	Vdc
Collector Current – Continuous	I_C	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73		mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R\theta JC$	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	MPS-A16 MPS-A17	BV_{EBO}	12 15	– –	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	200	600	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-A16 MPS-A17	f_T	100 80	– –	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	4.0	pF



All JEDEC dimensions and notes apply

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

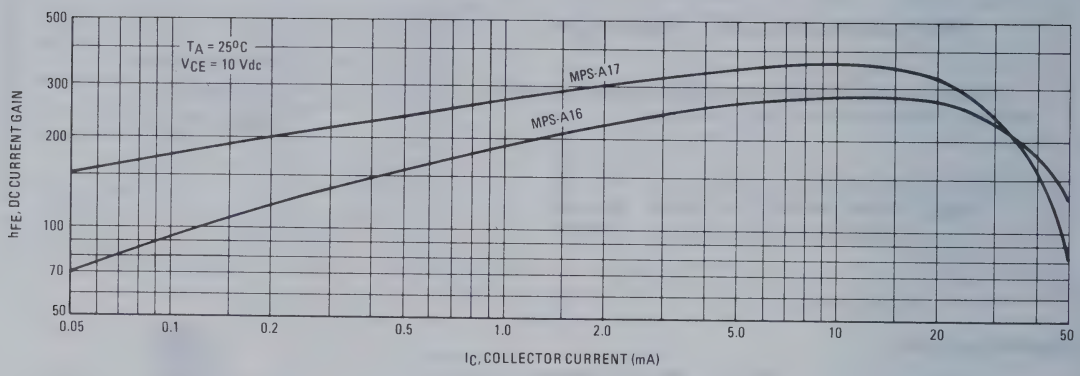


FIGURE 2 – SMALL SIGNAL CURRENT GAIN

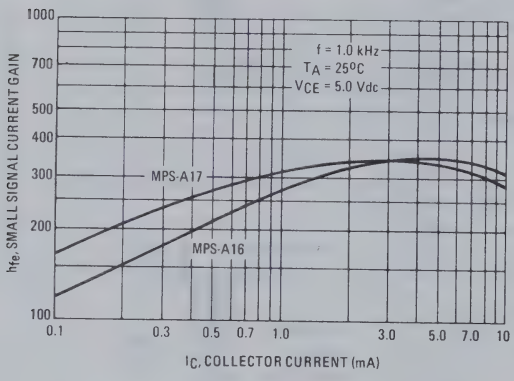


FIGURE 3 – SATURATION AND ON VOLTAGES

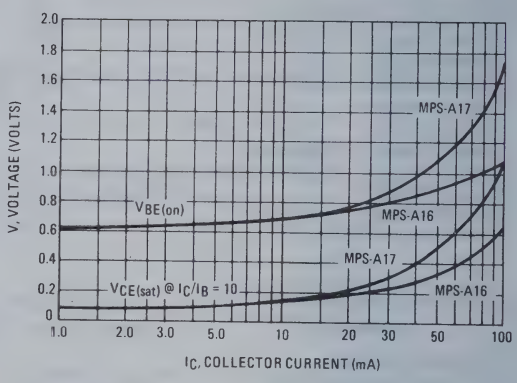


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

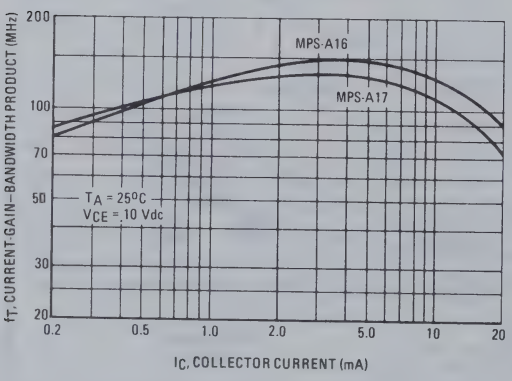
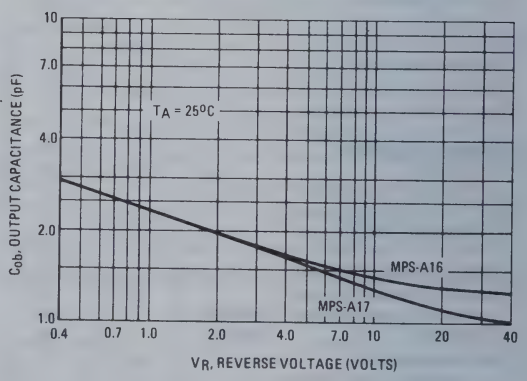


FIGURE 5 – OUTPUT CAPACITANCE



MPS-A18 (SILICON)

Advance Information

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for low level, low noise amplifier applications with excellent gain linearity from 10 μA to 10 mA.

- Noise Figure –
  NF @ 10 Hz – 5.0 dB (Typ)
  @ Wide Band, 10 Hz to 15.7 kHz – 0.5 dB (Typ)
- DC Current Gain –
  h_{FE} @ 10 μAdc – 525 (Typ)
  @ 1.0 mAdc – 1500 (Typ)

NPN SILICON AMPLIFIER TRANSISTOR



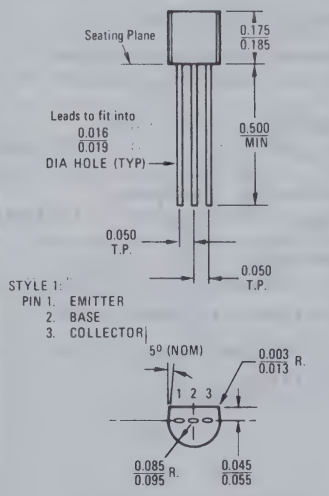
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	6.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	45	-	-	Vdc
Collector-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	1.0	50	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		400	525	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		500	725	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		800	1500	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		500	-	1500	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)		-	0.1	0.2	
(I_C 50 mAdc, I_B = 5.0 mAdc)		-	0.15	0.3	
Base Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	0.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	140	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	1.3	3.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	-	5.0	6.5	pF
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz)		-	0.5	1.5	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 10 Hz)		-	5.0	-	

MPS-A20 (SILICON)
MPS-K20, MPS-K21, MPS-K22

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in audio, radio, and television applications.

- MPS-K20, MPS-K21, MPS-K22 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc

NPN SILICON AMPLIFIER TRANSISTORS



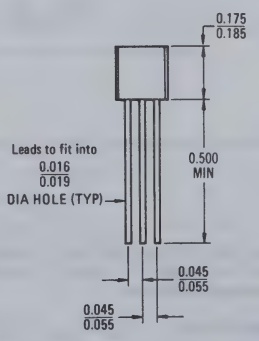
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.367	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

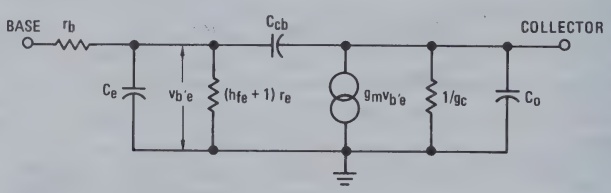


CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A20 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

$C_{cb} = C_{ob} - 0.2\ pF$ (See Figure 6)

$g_m = 1/r_e$

$g_c = (h_{fe}+1)\,h_{ob}$ (See Figures 2 & 7)

$C_o = 0.2\ pF$

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe}+1)\,r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe}+1)\,h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

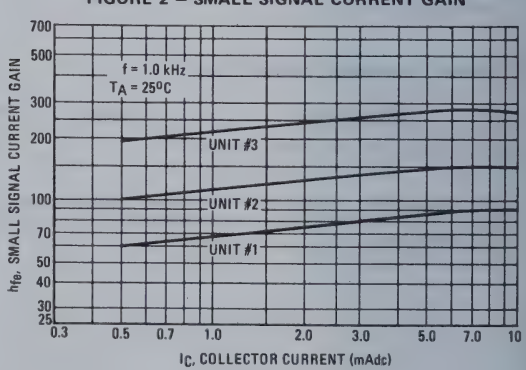


FIGURE 3 – NORMALIZED DC CURRENT GAIN

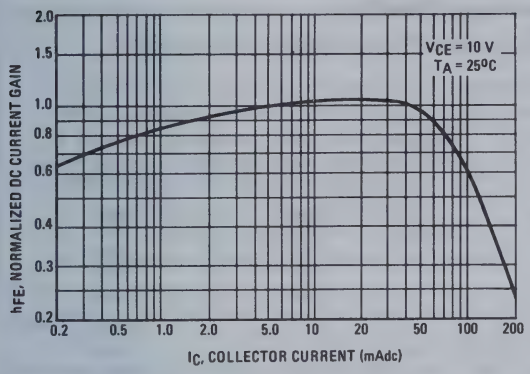


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

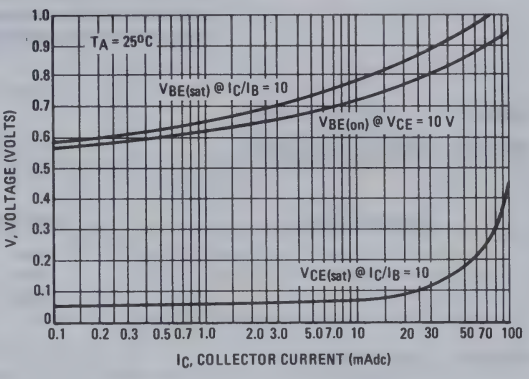


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

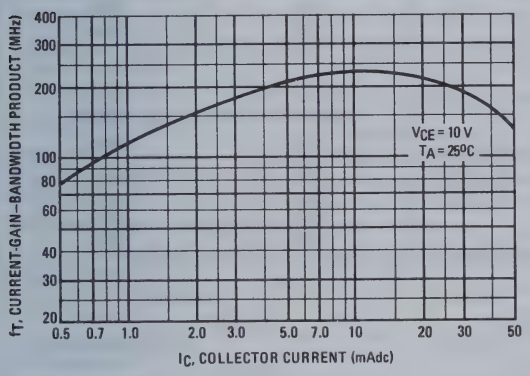


FIGURE 6 – CAPACITANCES

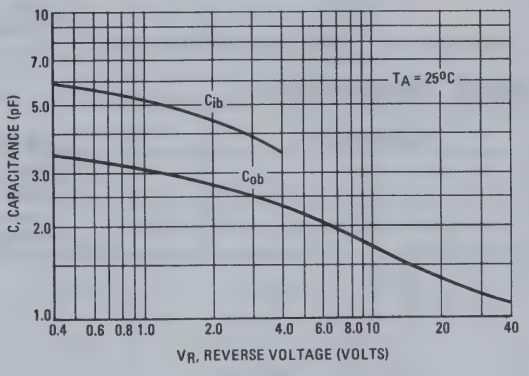


FIGURE 7 – OUTPUT ADMITTANCE

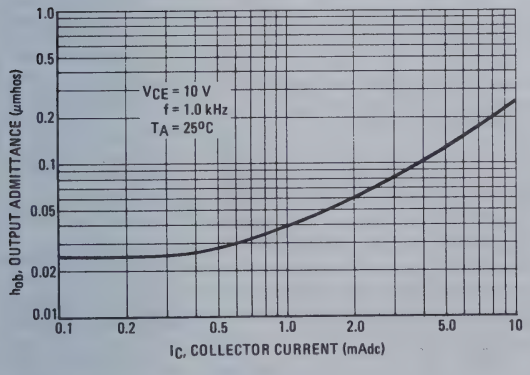
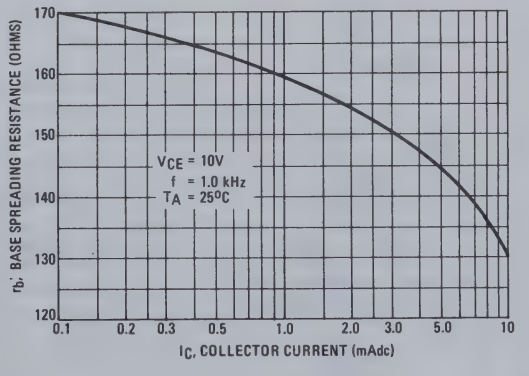


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K20, MPS-K21 and MPS-K22 are three, five and nine transistor kits consisting of MPS-A20's with various h_{FE} selections.

Table 1

MPS-K20 — Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K21 — Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K22 — Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

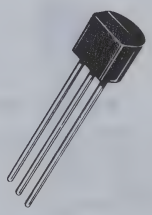
MPS-A42 (SILICON)
MPS-A43

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- High Collector-Emitter Breakdown Voltage @ I_C = 1.0 mAdc — BV_{CEO} = 300 Vdc (Min) — MPS-A42
  200 Vdc (Min) — MPS-A43
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 20 mAdc
- Complements to PNP Types MPS-A92 and MPS-A93

NPN SILICON HIGH VOLTAGE TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MPS-A42	MPS-A43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CB}	300	200	Vdc
Emitter-Base Voltage	V_{EB}	6.0	6.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

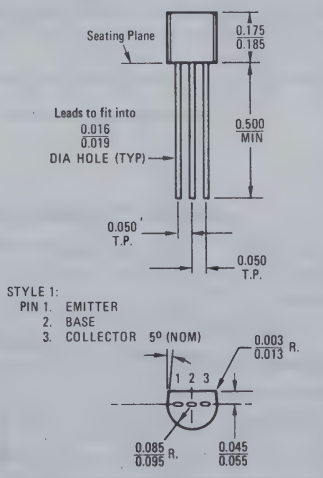
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1] (I_C = 1.0 mAdc, I_B = 0)	MPS-A42 MPS-A43	BV_{CEO}	300 200	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-A42 MPS-A43	BV_{CBO}	300 200	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	MPS-A42 MPS-A43	BV_{EBO}	6.0 6.0	– –	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	 MPS-A42 MPS-A43	I_{CBO}	 – –	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0) (V_{BE} = 4.0 Vdc, I_C = 0)	 MPS-A42 MPS-A43	I_{EBO}	 – –	 0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	 Both Types Both Types MPS-A42 MPS-A43	h_{FE}	 25 40 40 50	 – – – 200	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MPS-A42 MPS-A43	$V_{CE(sat)}$	– –	0.5 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPS-A42 MPS-A43	C_{cb}	– –	3.0 4.0	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

FIGURE 1 – DC CURRENT GAIN

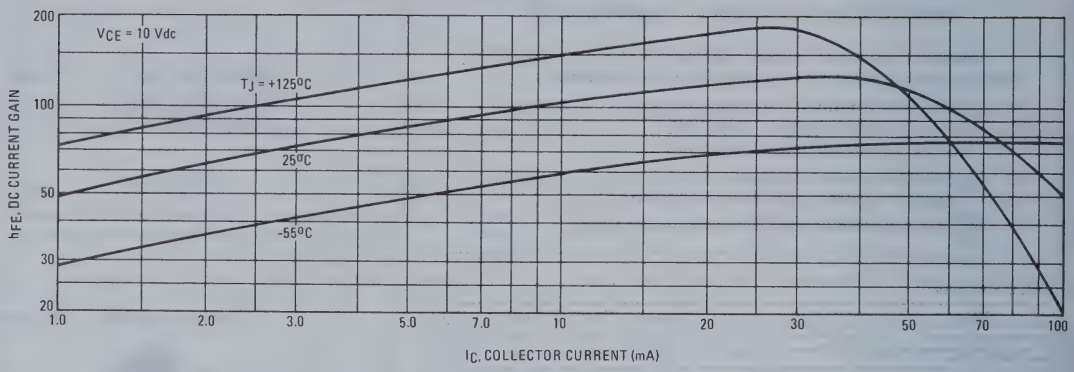


FIGURE 2 – CAPACITANCES

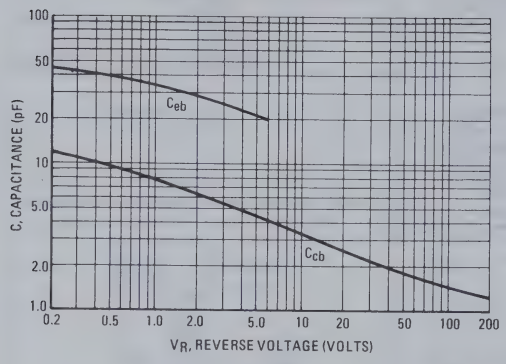


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

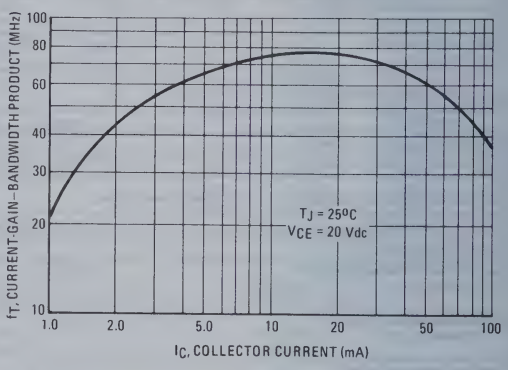


FIGURE 4 – "ON" VOLTAGES

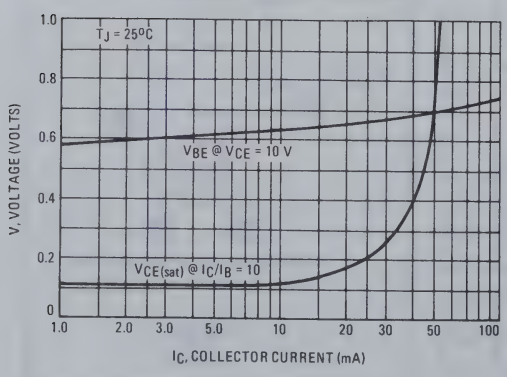
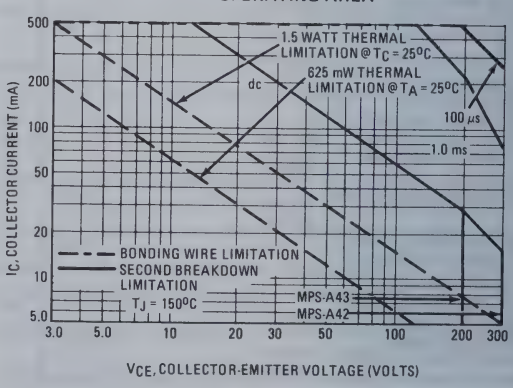


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



MPS-A55 (SILICON)
MPS-A56

PNP SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for use as medium-power drivers and low-power outputs.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-A55
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-A56
- Excellent Current-Gain Linearity – 1.0 mAdc to 200 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 100 mAdc
- Complements to MPS-A05 and MPS-A06

PNP SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MPS-A55	MPS-A56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4.54		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D (1)	800 7.27		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

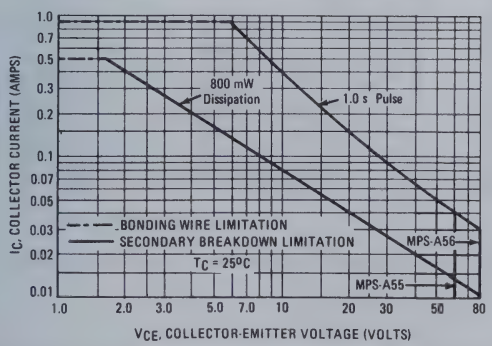
THERMAL CHARACTERISTICS

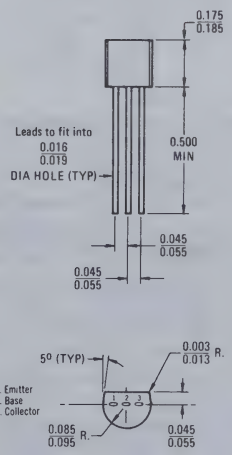
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA} ** (1)	0.220	°C/mW

** θ_{JA} is measured with the device soldered into a typical printed circuit board.

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.

FIGURE 1 – DC SAFE OPERATING AREA





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TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-A55	BV_{CEO}	60	–	–	Vdc
	MPS-A56		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MPS-A55		–	–	100	
(V_{CB} = 80 Vdc, I_E = 0)	MPS-A56		–	–	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			50	150	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	125	–	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)			–	80	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	–	0.09	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	–	0.78	–	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.73	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		f_T	100	175	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.5	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	20	–	pF

FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

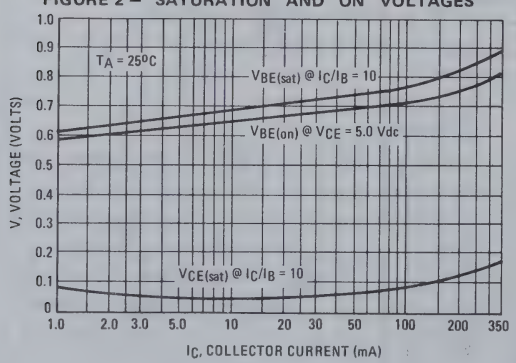
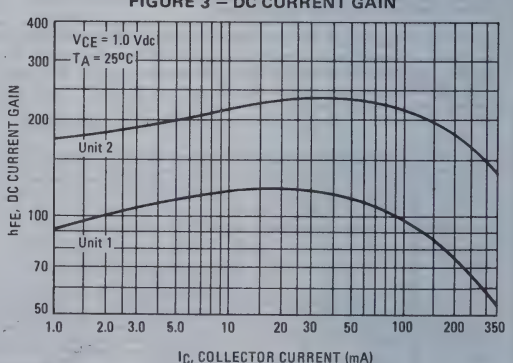


FIGURE 3 – DC CURRENT GAIN



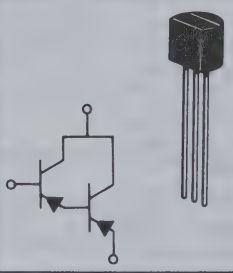
MPS-A65 (SILICON)
MPS-A66

PNP SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain –
  h_{FE} = 50,000 (Min) @ I_C = 10 mAdc (MPS-A65)
  75,000 (Min) @ I_C = 10 mAdc (MPS-A66)
- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc

PNP SILICON DARLINGTON TRANSISTORS



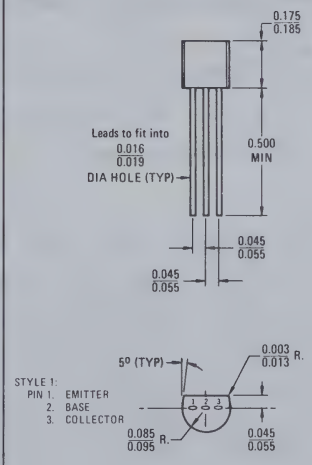
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current – Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4 54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.220	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)		BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65		50,000	–	–	
	MPS-A66		75,000	–	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65		20,000	–	–	
	MPS-A66		40,000	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.9	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.45	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	175	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.5	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)		NF	–	2.0	–	dB

FIGURE 1 – NORMALIZED DC CURRENT GAIN

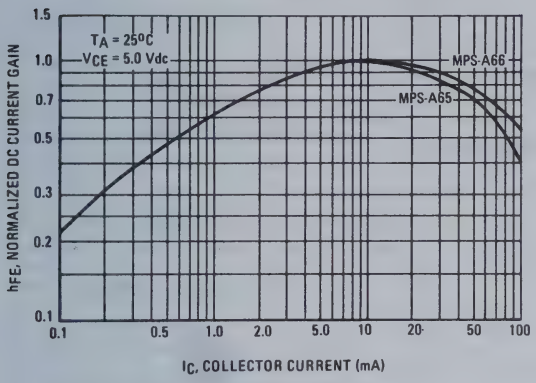


FIGURE 2 – BASE-EMITTER "ON" VOLTAGE

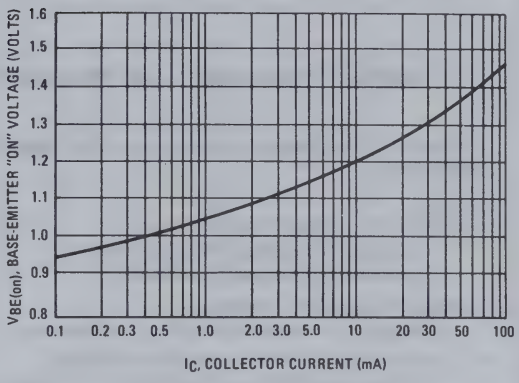


FIGURE 3 – TRANSCONDUCTANCE versus FREQUENCY

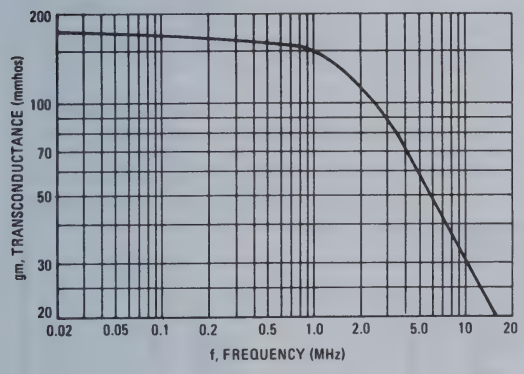


FIGURE 4 – NOISE FIGURE versus CURRENT

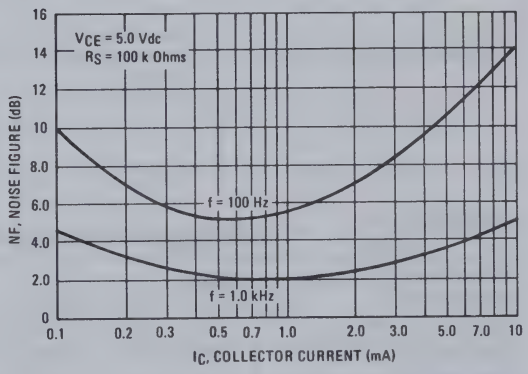


FIGURE 5 – NOISE FIGURE versus FREQUENCY

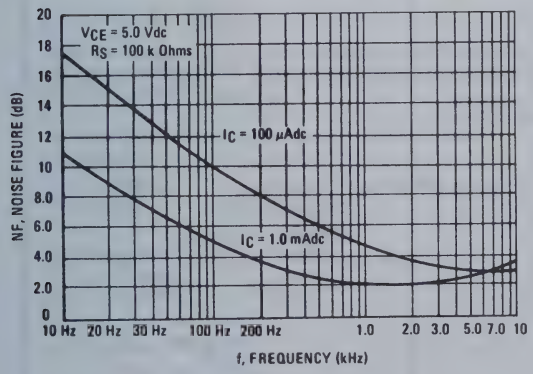
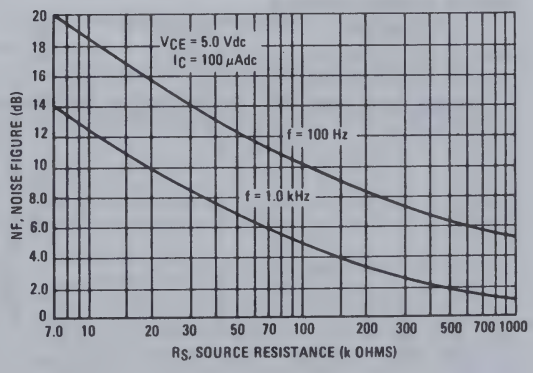


FIGURE 6 – NOISE FIGURE versus SOURCE RESISTANCE



MPS-A70 (SILICON)
MPS-K70, MPS-K71
MPS-K72

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose use in audio, radio, and television applications.

- MPS-K70, MPS-K71, MPS-K72 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc

PNP SILICON AMPLIFIER TRANSISTORS



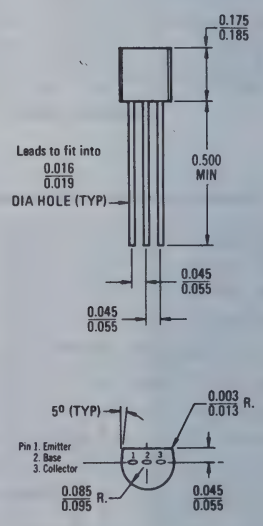
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.367	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

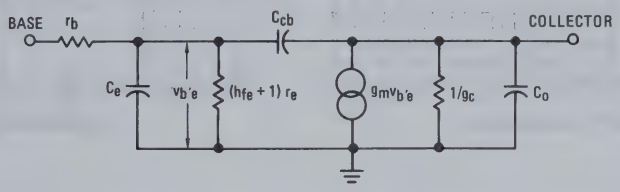


CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A70 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b – See Figure 8 $\quad C_{cb} = C_{ob} - 0.2$ pF (See Figure 6)

$r_e = 26\ mV/I_E \quad g_m = 1/r_e$

$C_e = \dfrac{1}{2\pi f_t r_e} \quad g_c = (h_{fe}+1)\,h_{ob}$ (See Figures 2 & 7)

$C_o = 0.2$ pF

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe}+1)\,r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe}+1)\,h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

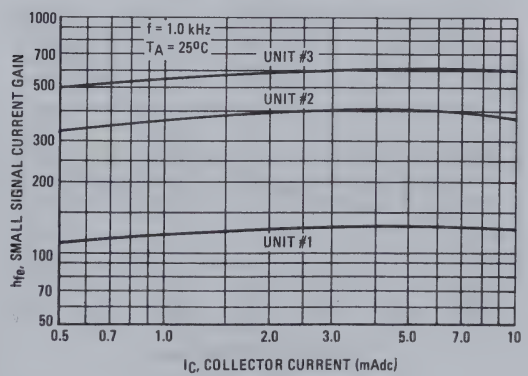


FIGURE 3 – NORMALIZED DC CURRENT GAIN

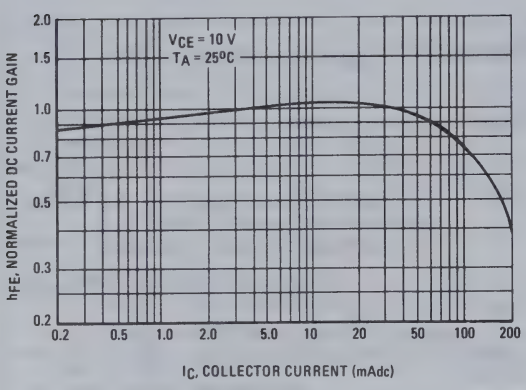


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

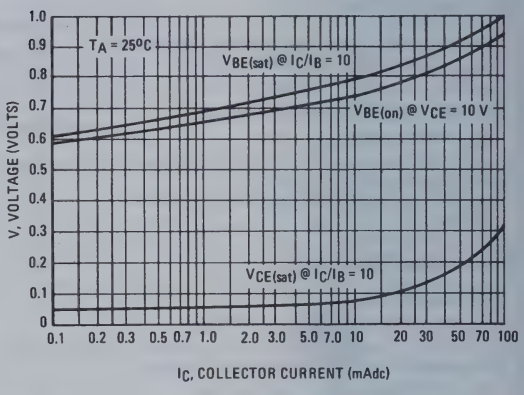


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

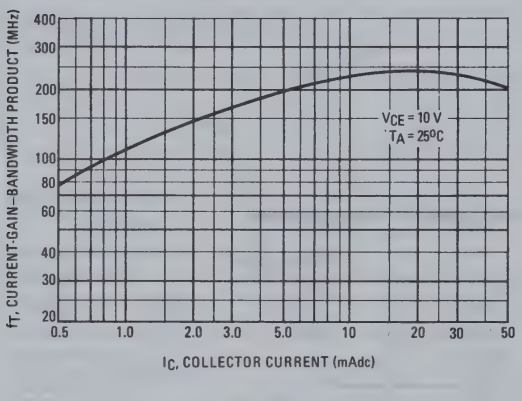


FIGURE 6 – CAPACITANCES

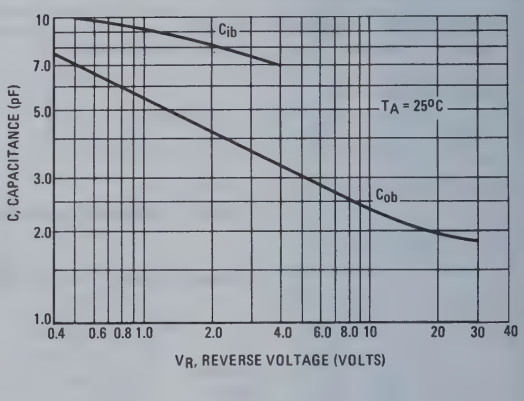


FIGURE 7 – OUTPUT ADMITTANCE

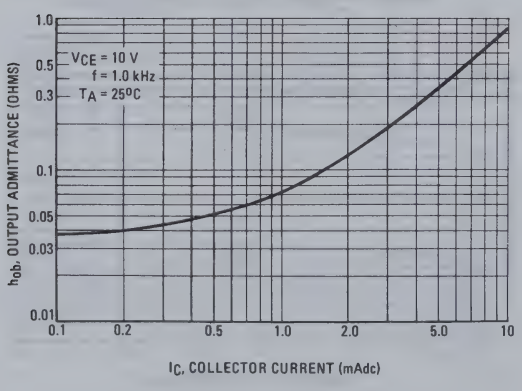
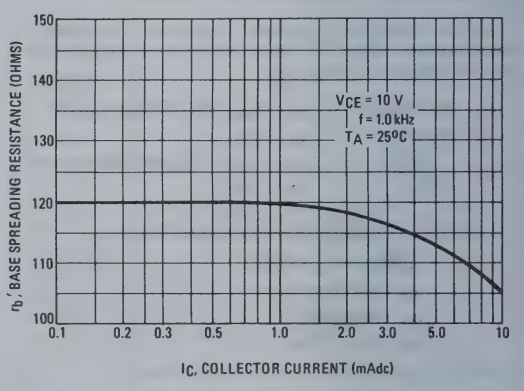


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K70, MPS-K71and MPS-K72 are three, five and nine transistor kits consisting of MPS-A70's with various h_{FE} selections.

Table 1

MPS-K70 — Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K71 — Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K72 — Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

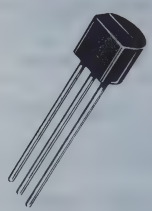
MPS-A92 (SILICON)
MPS-A93

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- High Collector-Emitter Breakdown Voltage @ I_C = 1.0 mAdc — BV_{CEO} = 300 Vdc (Min) — MPS-A92
  200 Vdc (Min) — MPS-A93
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 20 mAdc
- Complements to NPN Types MPS-A42 and MPS-A43

PNP SILICON HIGH VOLTAGE TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CB}	300	200	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C

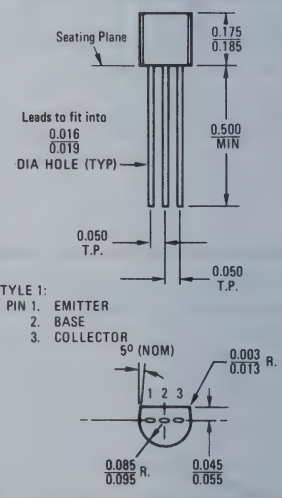
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MPS-A92 MPS-A93	BV_{CEO}	300 200	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-A92 MPS-A93	BV_{CBO}	300 200	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MPS-A92 MPS-A93	I_{CBO}	– –	0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MPS-A92 MPS-A93	h_{FE}	25 40 25 30	– – – 150	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MPS-A92 MPS-A93	$V_{CE(sat)}$	– –	0.8 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPS-A92 MPS-A93	C_{cb}	– –	6.0 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-02
TO-92
PLASTIC

FIGURE 1 – DC CURRENT GAIN

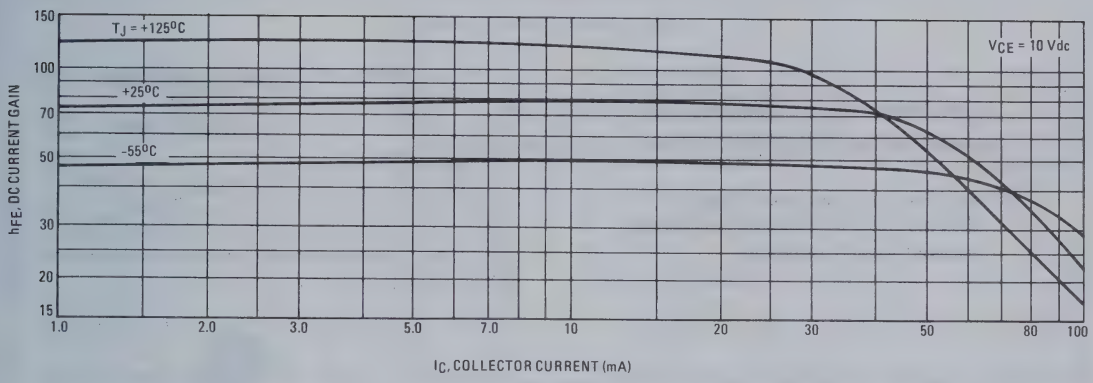


FIGURE 2 – CAPACITANCES

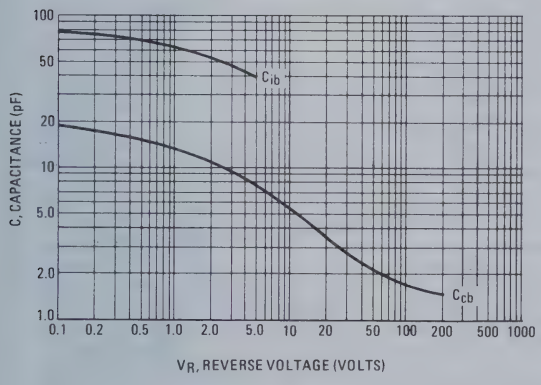


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

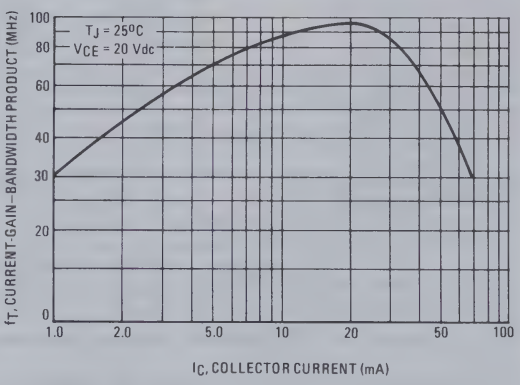


FIGURE 4 – "ON" VOLTAGES

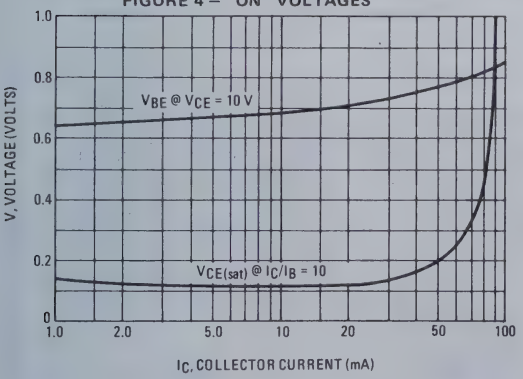
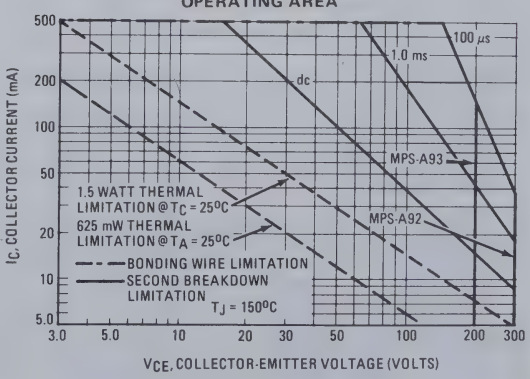


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



MPS-D01 NPN (SILICON)
MPS-D51 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in electronic calculators using gas discharge tubes.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 200 Vdc (Min) @ I_C = 1.0 mAdc
- Complete Typical Design Curves

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	200	Vdc
Collector-Base Voltage	V_{CB}	200	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

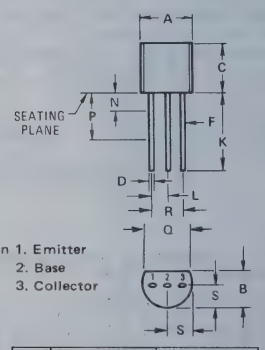
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	200	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	200	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0) (V_{CE} = 80 Vdc, V_{BE} = 0, T_A = 75°C)	I_{CES}	 – –	 0.1 4.0	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0, T_A = 75°C)	I_{CBO}	 – –	 0.1 4.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 20	 – –	–
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	–	MHz



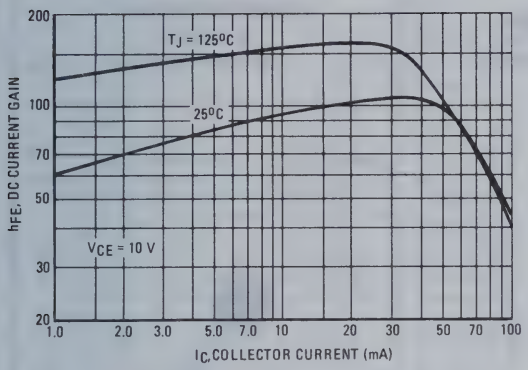
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

NPN
MPS-D01

PNP
MPS-D51

FIGURE 1 – DC CURRENT GAIN



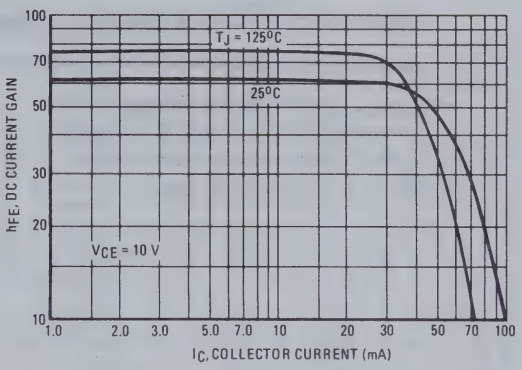
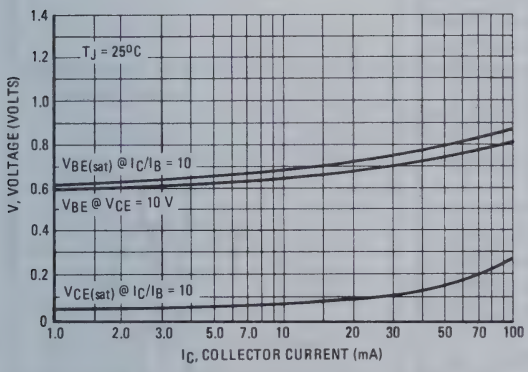


FIGURE 2 – "ON" VOLTAGES



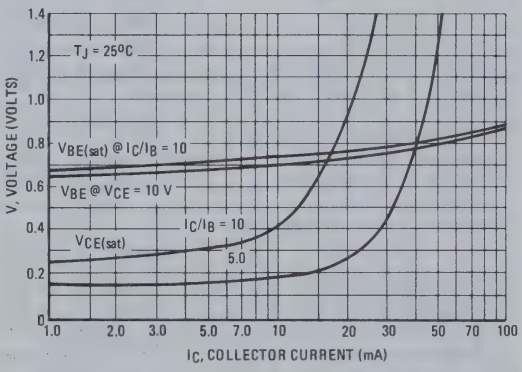


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

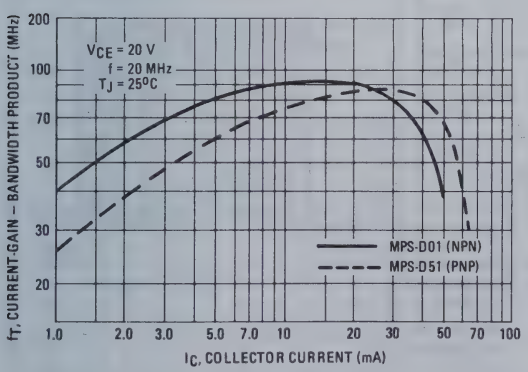
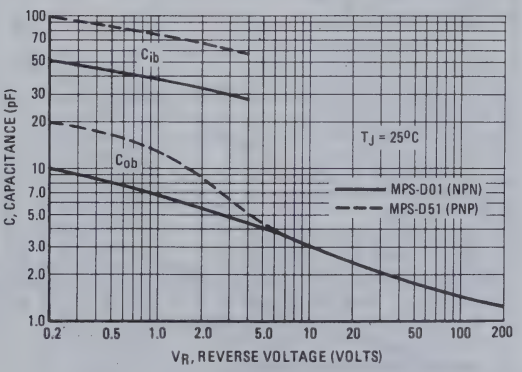


FIGURE 4 – CAPACITANCE



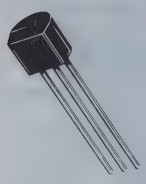
MPS-D02 NPN (SILICON)
MPS-D52 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in high voltage amplifier and driver applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 140 Vdc (Min) @ I_C = 1.0 mAdc
- Excellent for Nixie® Driver Applications
- Ideal for Calculator Display Design

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

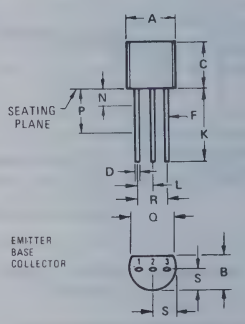
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	140	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25 20	– –	–
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	40	–	MHz



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

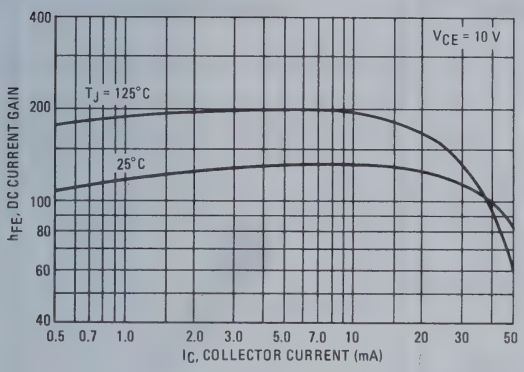
CASE 29-02
TO-92

® Trademark of Burroughs Corporation

NPN
MPS-D02

PNP
MPS-D52

FIGURE 1 – DC CURRENT GAIN



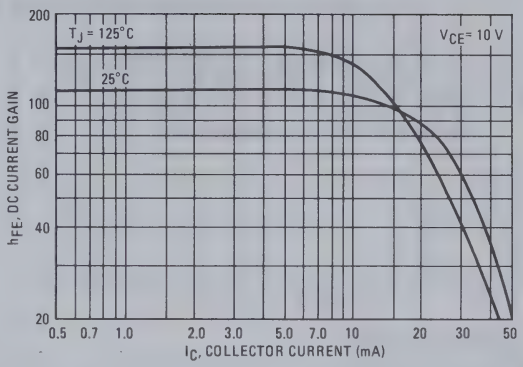
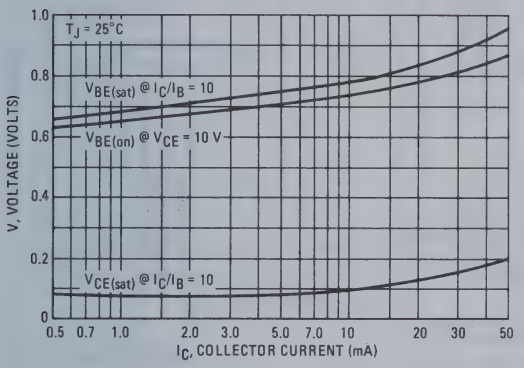


FIGURE 2 – "ON" VOLTAGES



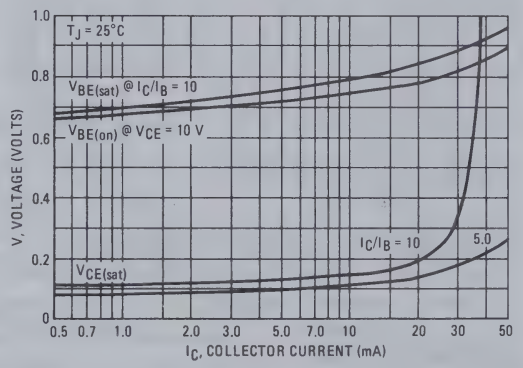


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

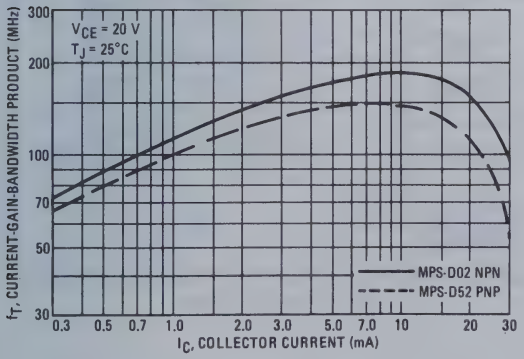
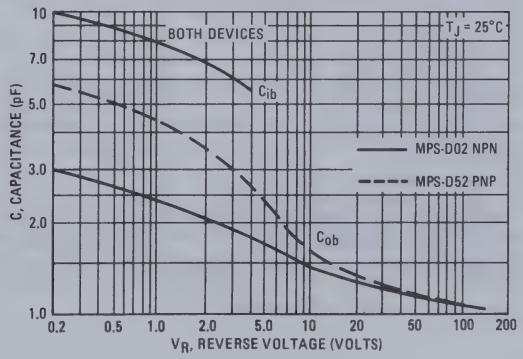


FIGURE 4 – CAPACITANCE



MPS-D03 NPN (SILICON)
MPS-D53 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in high voltage amplifier and driver applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- Excellent for Nixie ® Driver Applications
- Ideal for Calculator Display Design

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25° C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

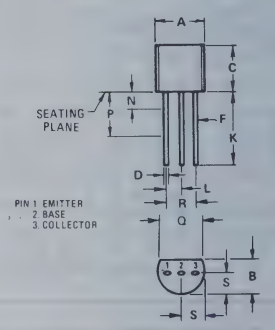
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25 20	– –	–
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	40	–	MHz



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

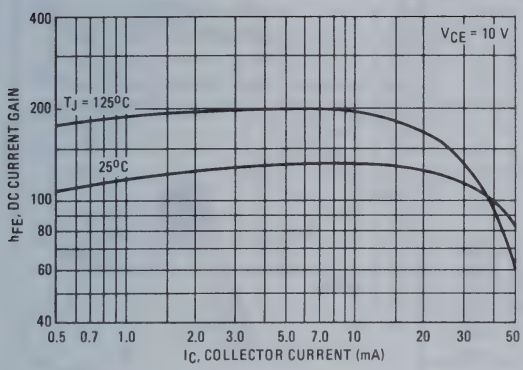
CASE 29-02
TO-92

® Trademark of Burroughs Corporation

NPN
MPS-D03

PNP
MPS-D53

FIGURE 1 – DC CURRENT GAIN



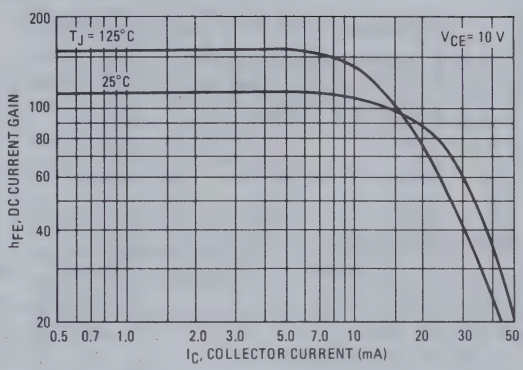
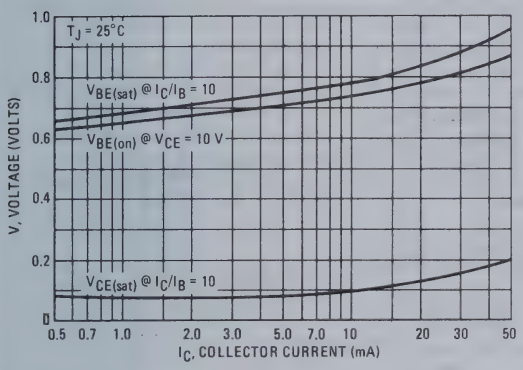


FIGURE 2 – "ON" VOLTAGES



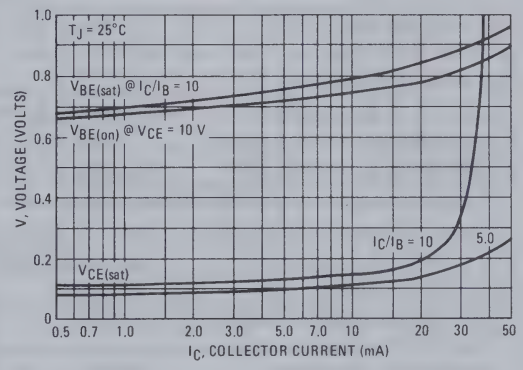


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

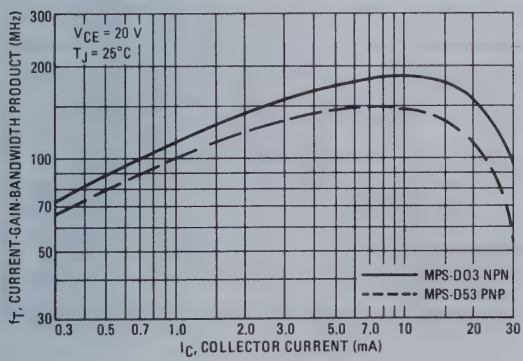
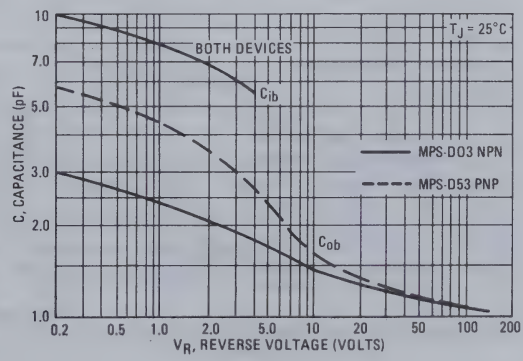


FIGURE 4 – CAPACITANCE



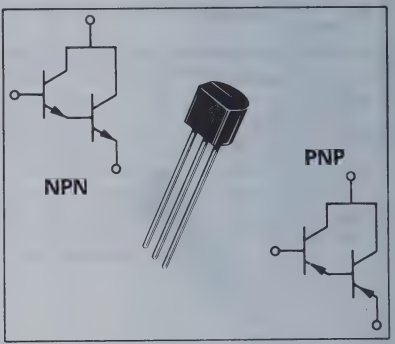
MPS-D04 NPN (SILICON)
MPS-D54 PNP

COMPLEMENTARY DARLINGTON SILICON ANNULAR TRANSISTORS

. . . designed for use in high gain driver applications.

- Excellent LED Digit Driver
- DC Current Gain Specified – 10 mAdc to 300 mAdc
- Monolithic Construction

COMPLEMENTARY SILICON DARLINGTON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

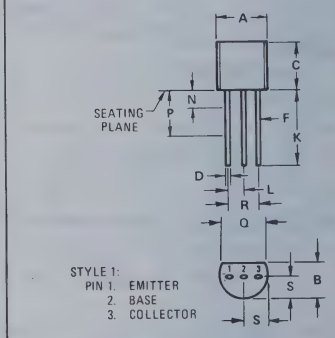
Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	200	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc, V_{BE} = 0$)	BV_{CES}	25	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc, I_C = 0$)	BV_{EBO}	10	–	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{CES}	–	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	1.0	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 1000 2000 1000	 – – –	–
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 100$ MHz)	f_T	100	–	MHz

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL CHARACTERISTICS

NPN
MPS-D04

PNP
MPS-D54

FIGURE 1 – DC CURRENT GAIN

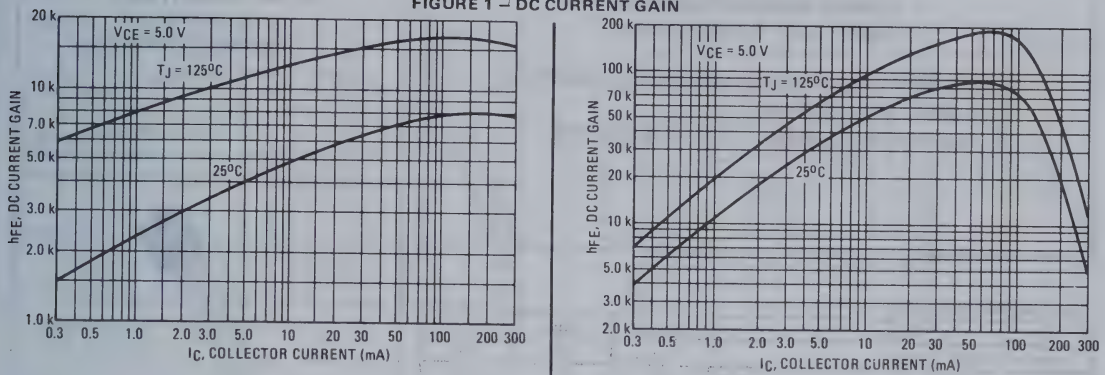


FIGURE 2 – "ON" VOLTAGES

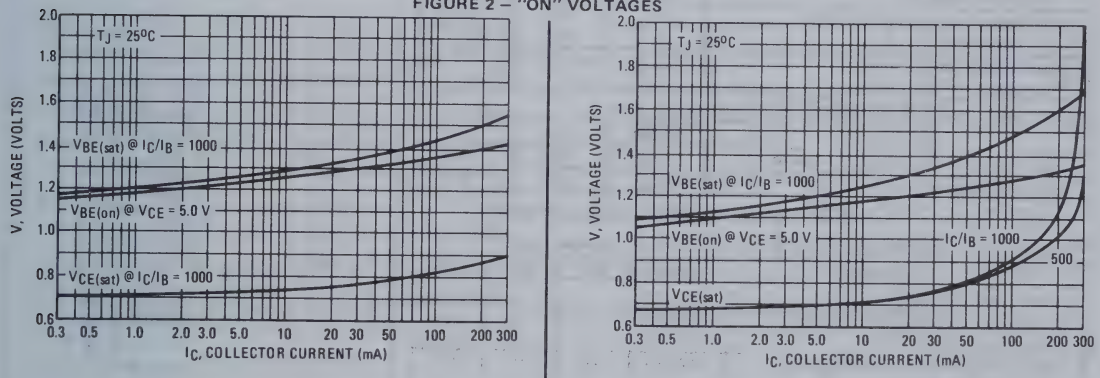


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

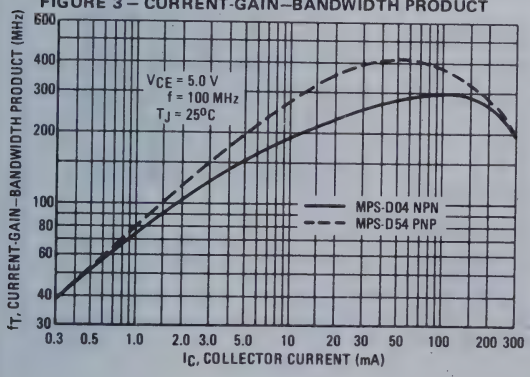
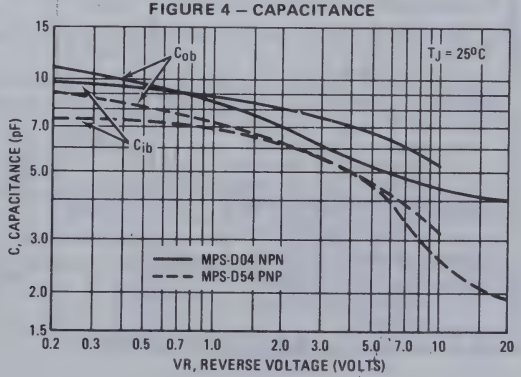


FIGURE 4 – CAPACITANCE



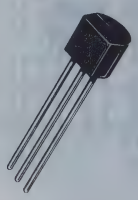
MPS-D05 NPN (SILICON)
MPS-D55 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in general purpose amplifier applications.

- Excellent LED Digit Driver
- DC Current Gain Specified – 50 mAdc to 500 mAdc

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

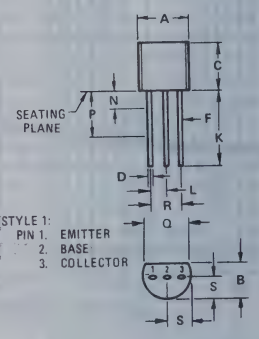
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	–	1.0	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 50 80 30	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
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L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

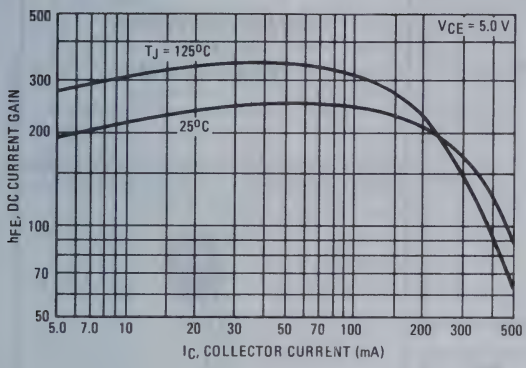
CASE 29-02
TO-92

TYPICAL CHARACTERISTICS

NPN
MPS-D05

PNP
MPS-D55

FIGURE 1 – DC CURRENT GAIN



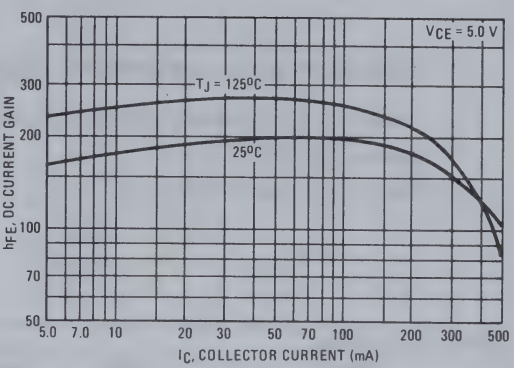
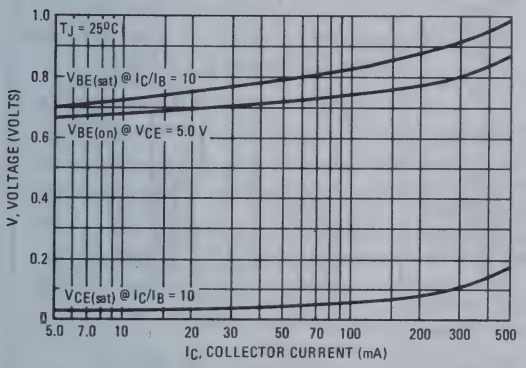


FIGURE 2 – "ON" VOLTAGES



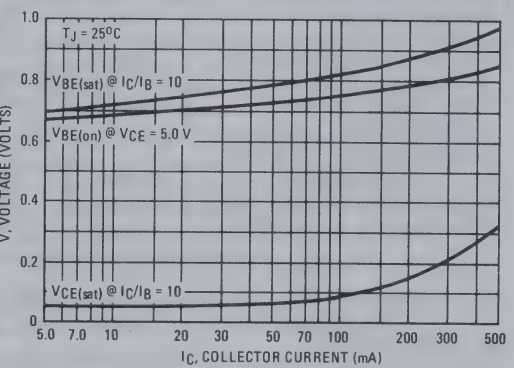


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

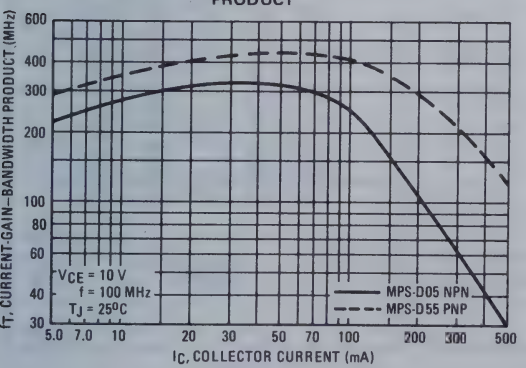
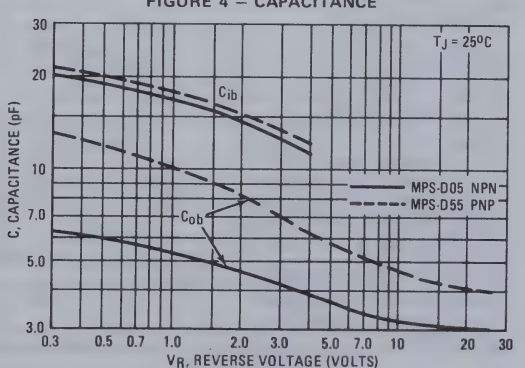


FIGURE 4 – CAPACITANCE



MPS-D06 NPN (SILICON)
MPS-D56 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in low voltage amplifier/driver circuits.

- Excellent LED Segment Driver
- Excellent Mini-Florescent Driver

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

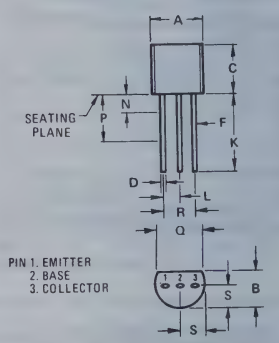
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	–	1.0	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 40 50 50	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	–	MHz



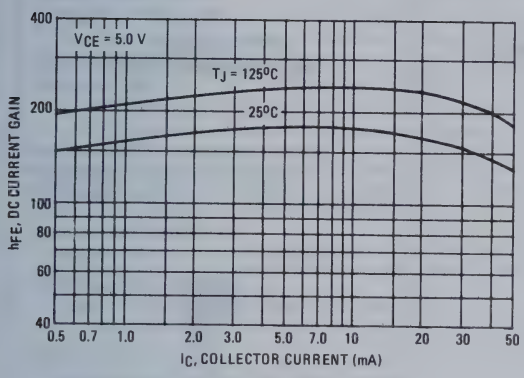
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

NPN
MPS-D06

PNP
MPS-D56

FIGURE 1 – DC CURRENT GAIN



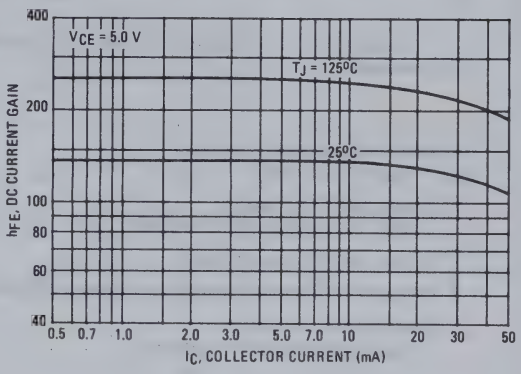
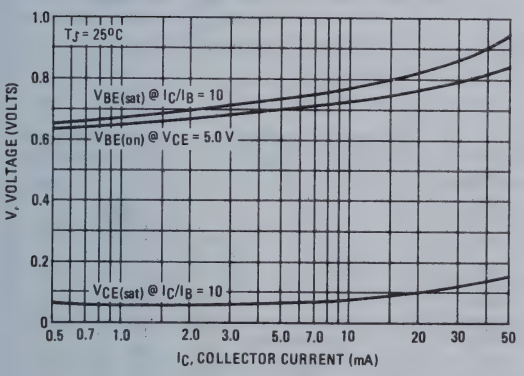


FIGURE 2 – "ON" VOLTAGES



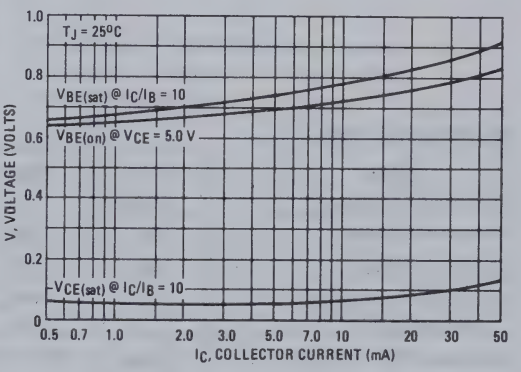


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

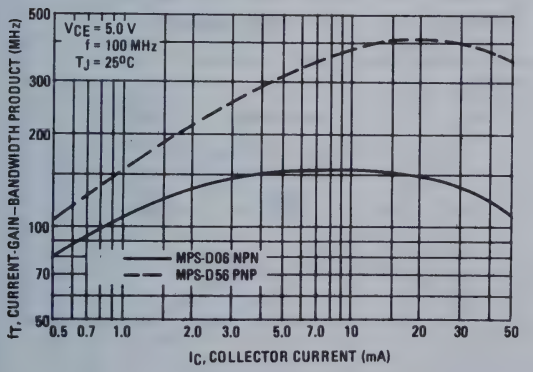
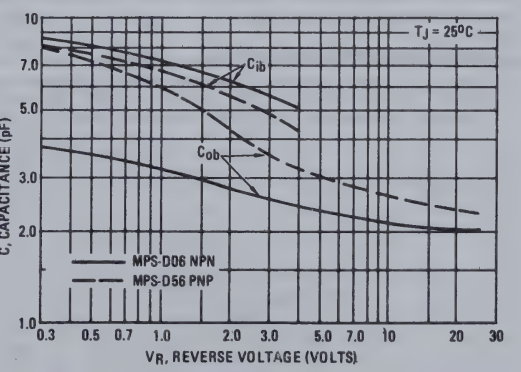


FIGURE 4 – CAPACITANCE



MPS-H02 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for a common-emitter VHF-RF amplifier stage in TV receivers.

- Low Collector-Base Capacitance — C_{cb} = 0.5 pF (Max)
- Guaranteed Noise Figure — NF = 3.3 dB (Max) @ f = 200 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves from 50 MHz to 300 MHz
- Guaranteed Power Gain — G_{pe} = 20 dB (Min) @ f = 200 MHz

NPN SILICON VHF TRANSISTOR



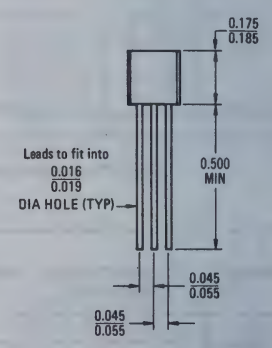
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.220	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



CASE 29 (2)
TO-92

MPS-H02 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	200	–
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	pF
Noise Figure (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	NF	–	3.3	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	G_{pe}	20	–	dB
Forward AGC Voltage (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS (V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9)

FIGURE 1 – POWER GAIN

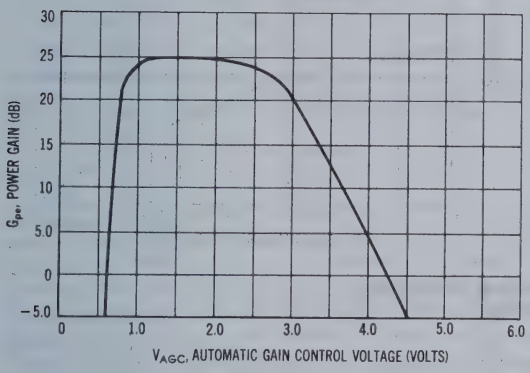
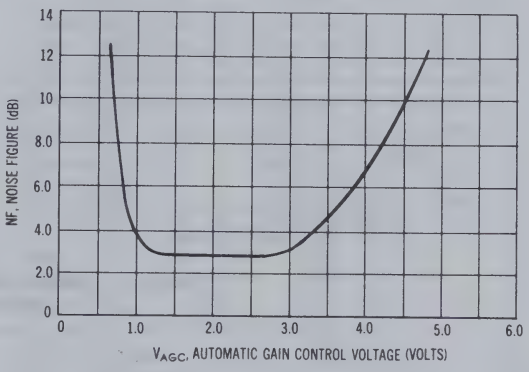


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

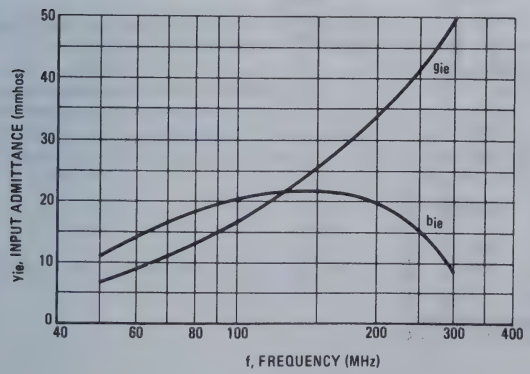
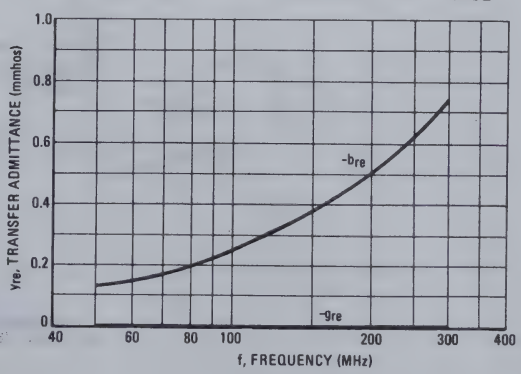


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

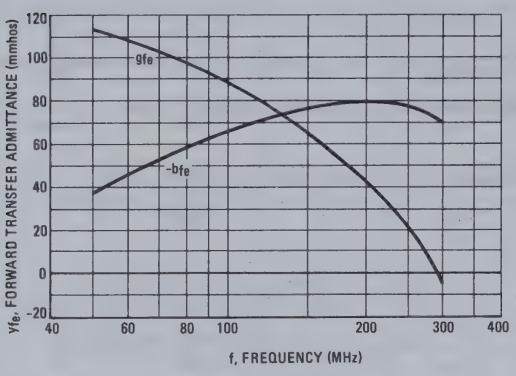


FIGURE 6 – OUTPUT ADMITTANCE

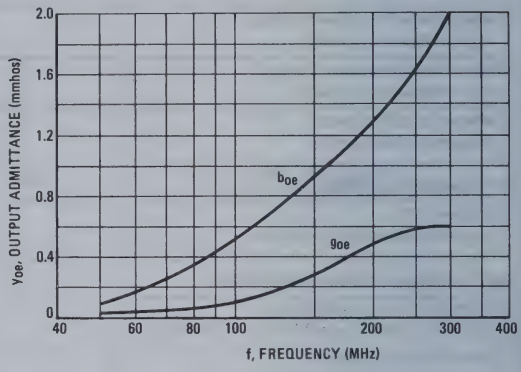


FIGURE 7 – DC CURRENT GAIN

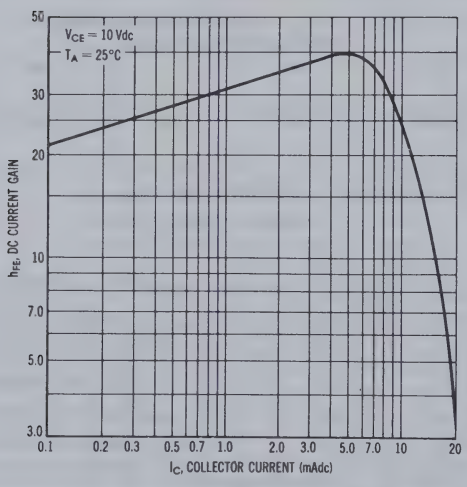


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

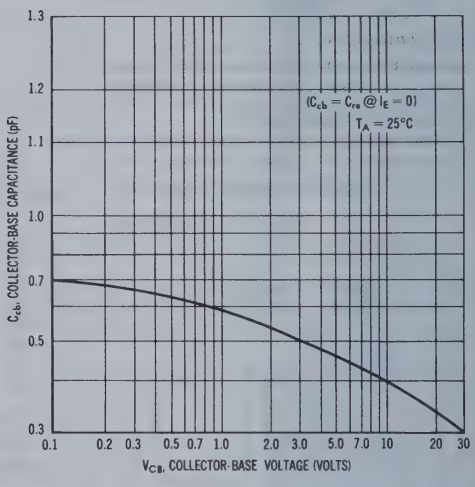
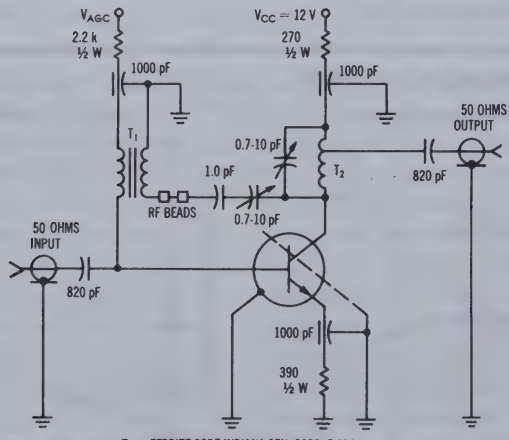


FIGURE 9 – 200 MHz FUNCTIONAL TEST CIRCUIT
(NEUTRALIZED)



T1 = FERRITE CORE INDIANA GEN. CORP. F-684
T2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾"

MPS-H04 (SILICON)
MPS-H05

NPN SILICON ANNULAR TRANSISTORS

. . . MPS-H04 is designed for RF amplifier applications in AM receivers.

. . . MPS-H05 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage – BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance – C_{cb} = 1.0 pF (Typ)
- Low Output Admittance – h_{oe} = 5.0 μmhos (Max)
- Low Noise Figure – NF = 2.0 dB (Max) – MPS-H04
- Complement to PNP MPS-H54, MPS-H55

NPN SILICON TRANSISTORS



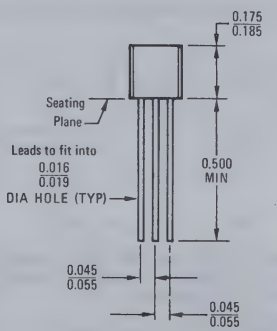
MAXIMUM RATINGS

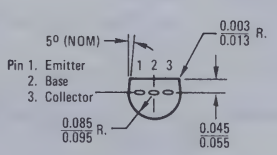
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA} (1)	0.367	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



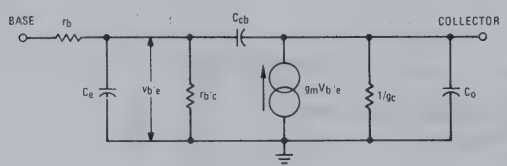


CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc)	MPS-H04 MPS-H05	h_{FE}	 30 30	 70 70	 120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.12	0.25	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	80	180	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{cb}	–	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	2.0	5.0	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz)	MPS-H04	NF	–	1.7	2.0	dB

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_{b'} \approx 15$ Ohms

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 3 and 6)

$C_o = 0.2$ pF

$r_{b'c} = (h_{fe} + 1)\, r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_{b'} + r_{b'c}$

$h_{fe} \approx 1.1\, h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega\,(C_e + C_{cb})\, r_{b'c}}{(r_{b'} + r_{b'c}) + j\omega\,(C_e + C_{cb})\, r_{b'} r_{b'c}}$$

$$y_{12} = \frac{j\omega\, C_{cb}}{j\omega\,(C_{cb} + C_e)\, r_{b'} + \dfrac{r_{b'} + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m \left(\frac{1}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}} \right) - \frac{j\omega\, C_{cb}}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}}$$

$$y_{22} = g_c + j\omega C_o - g_m r_{b'} y_{12} + \frac{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'} r_{b'c}} + j\omega\, C_e\right)\left(j\omega\, C_{cb}\right)}{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'} r_{b'c}} + j\omega\,(C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

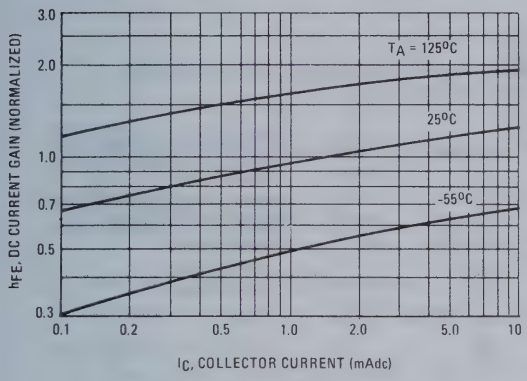


FIGURE 3 – "ON" VOLTAGES

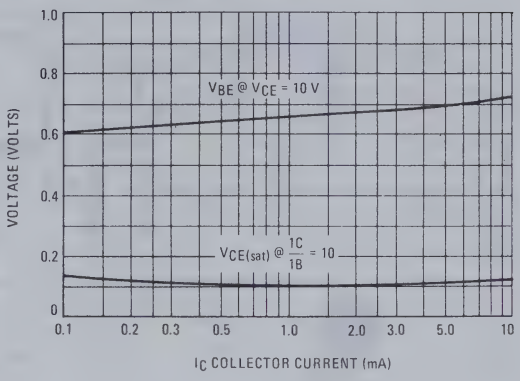


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

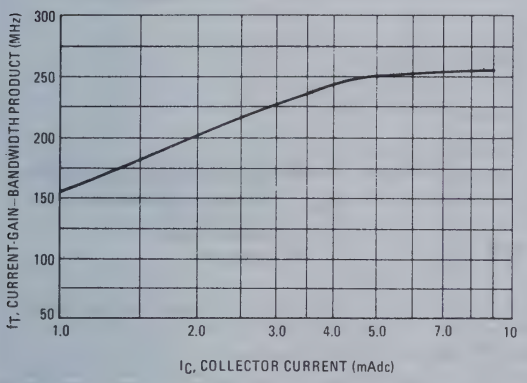


FIGURE 5 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

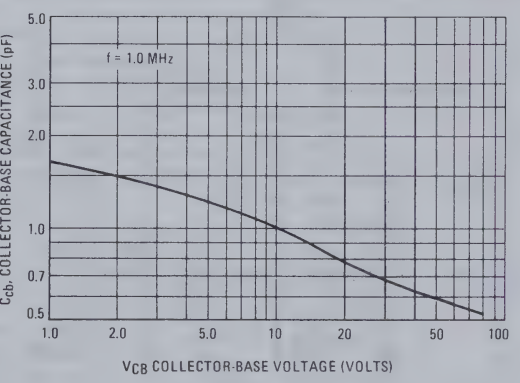


FIGURE 6 – OUTPUT ADMITTANCE

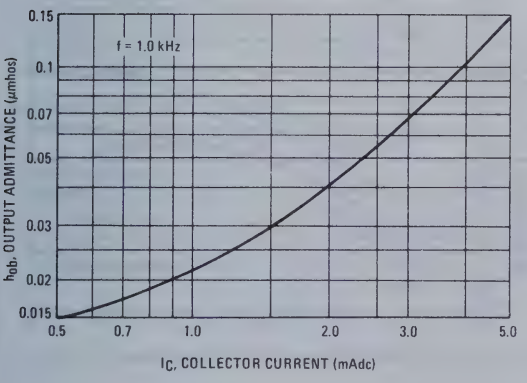
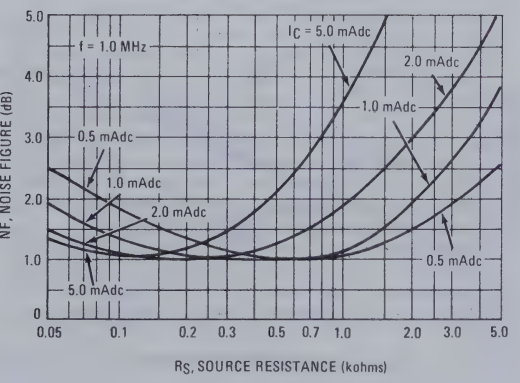
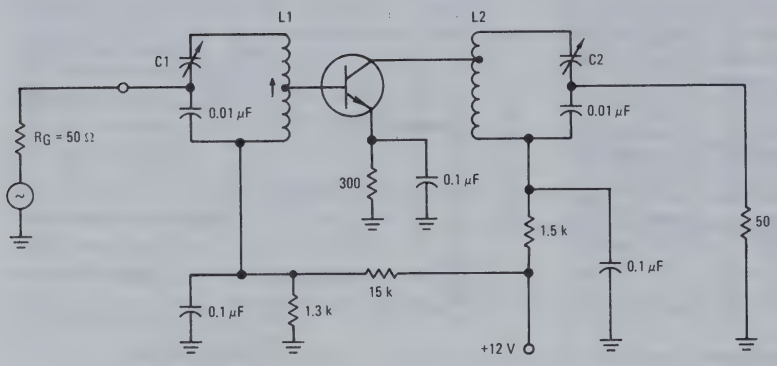


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT



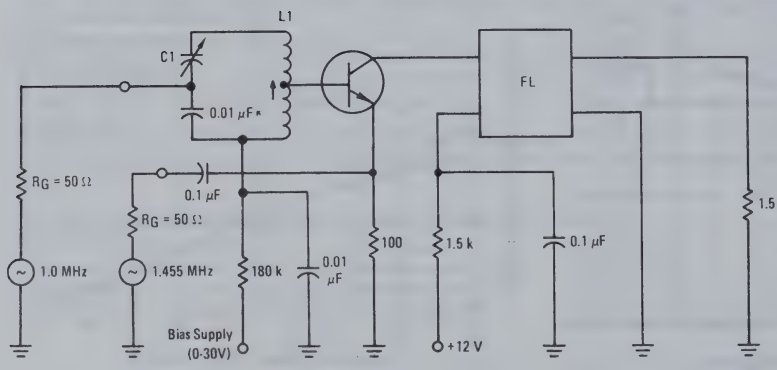
L1 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_U \approx 130$ Loaded Q, $Q_L \approx 60$

L2 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 21 turns from high end. Turns ratio of coil ≈ 1.3, unloaded Q, $Q_U \approx 130$, Loaded Q, $Q_L \approx 60$

C1 25-280 pF Variable

C2 100-400 pF Variable

FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT



L1 90 turns of 7 x 41 Litz wire on 1/4" form; tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_U \approx 130$, Loaded Q, $Q_L \approx 60$.

C1 25-280 pF Variable

FL 455 kHz Filter

FIGURE 10 – AMPLIFIER POWER GAIN

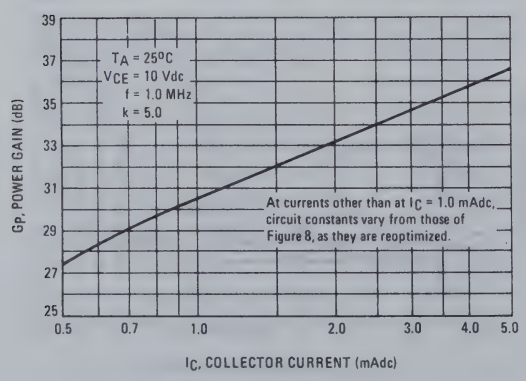
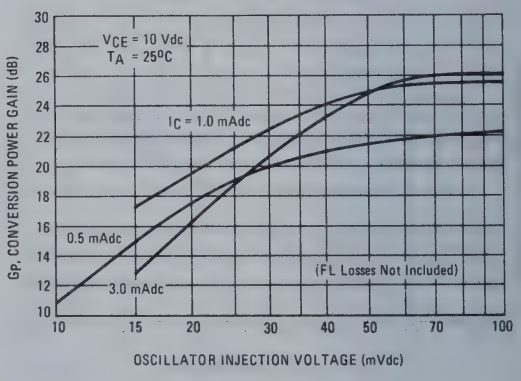


FIGURE 11 – CONVERSION POWER GAIN



MPS-H07 (SILICON)
MPS-H08

NPN SILICON ANNULAR TRANSISTORS

. . . designed for common-base FM/VHF RF amplifier applications.

- Guaranteed Noise Figure –
  NF = 3.2 dB (Max) @ f = 100 MHz MPS-H07
  = 3.5 dB (Max) @ f = 200 MHz MPS-H08
- Guaranteed Forward AGC Characteristics
- Complete y-Parameter Curves at Both 100 MHz and 200 MHz
- Guaranteed Power Gain –
  G_{pb} = 18 dB (Min) @ f = 100 MHz MPS-H07
  = 14 dB (Min) @ f = 200 MHz MPS-H08
- Low Feedback Capacitance Allowing Stable Unneutralized Operation

NPN SILICON FM/VHF TRANSISTORS



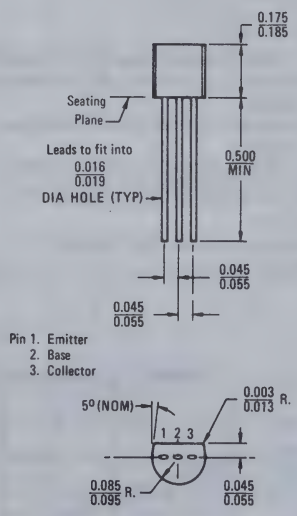
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	–	–
Base-Emitter On Voltage (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-H07 MPS-H08	f_T	400 500	– –	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)		C_{ce} (C_{rb})	–	0.3	pF
Noise Figure (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H07 MPS-H08	NF	– –	3.2 3.5	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms f = 100 MHz) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H07 MPS-H08	G_{pb}	18 14	– –	dB
Forward AGC Current (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 100 MHz) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	MPS-H07 MPS-H08	I_{AGC}	5.0 5.0	8.0 8.0	mAdc

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz – – – f = 200 MHz

FIGURE 1 – POWER GAIN

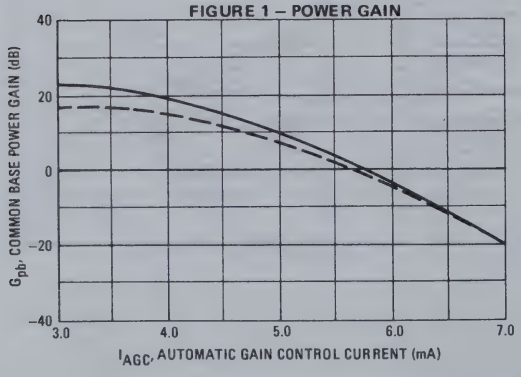
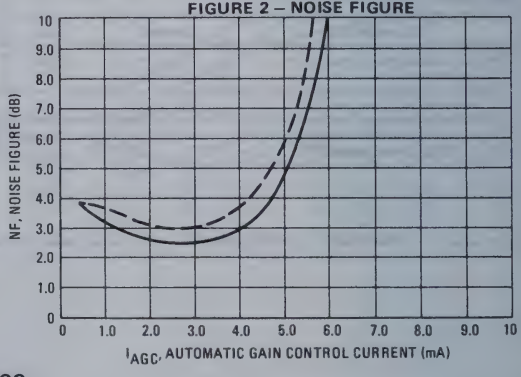


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, T_A = 25°C

—— f = 100 MHz ——— f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

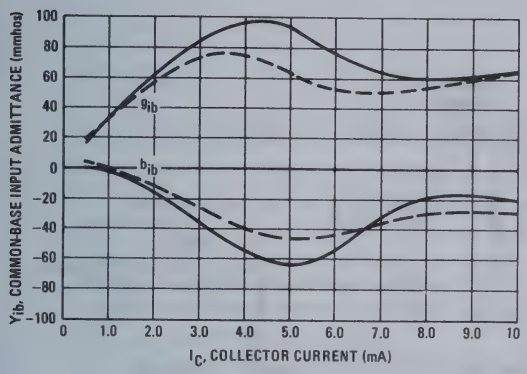


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

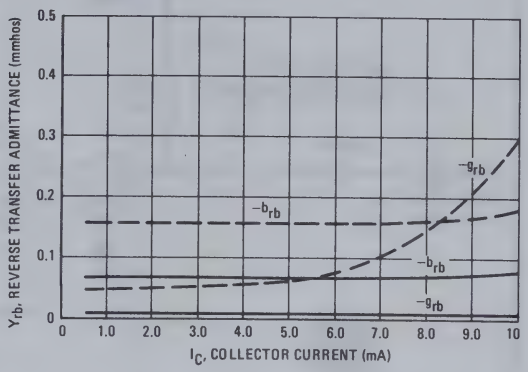


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

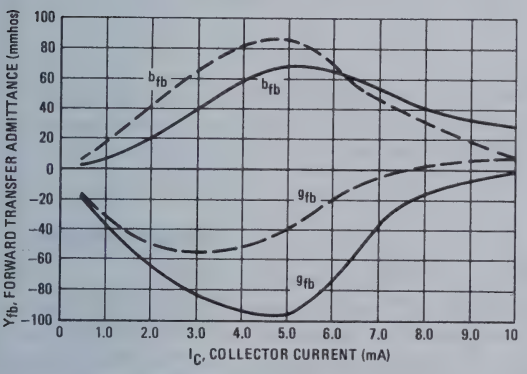


FIGURE 6 – OUTPUT ADMITTANCE

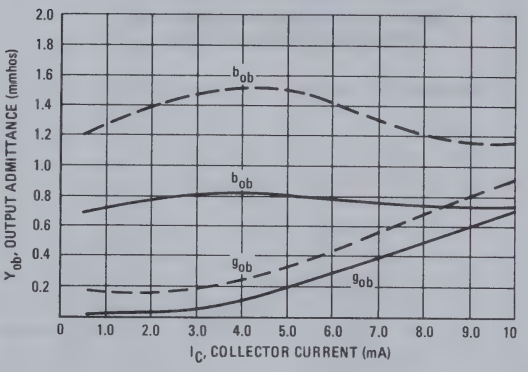


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

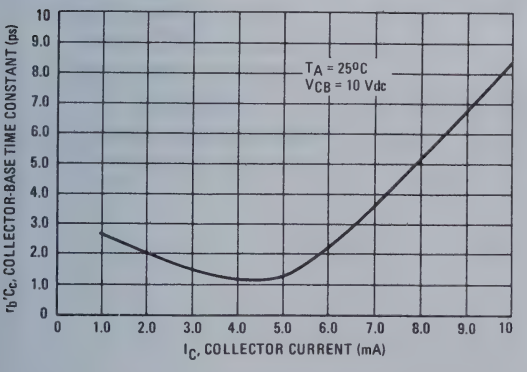


FIGURE 8 – CURRENT-GAIN BANDWIDTH PRODUCT

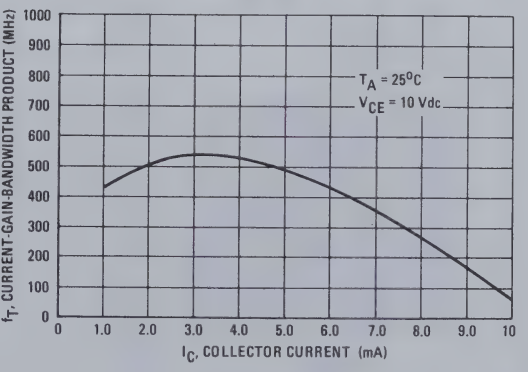
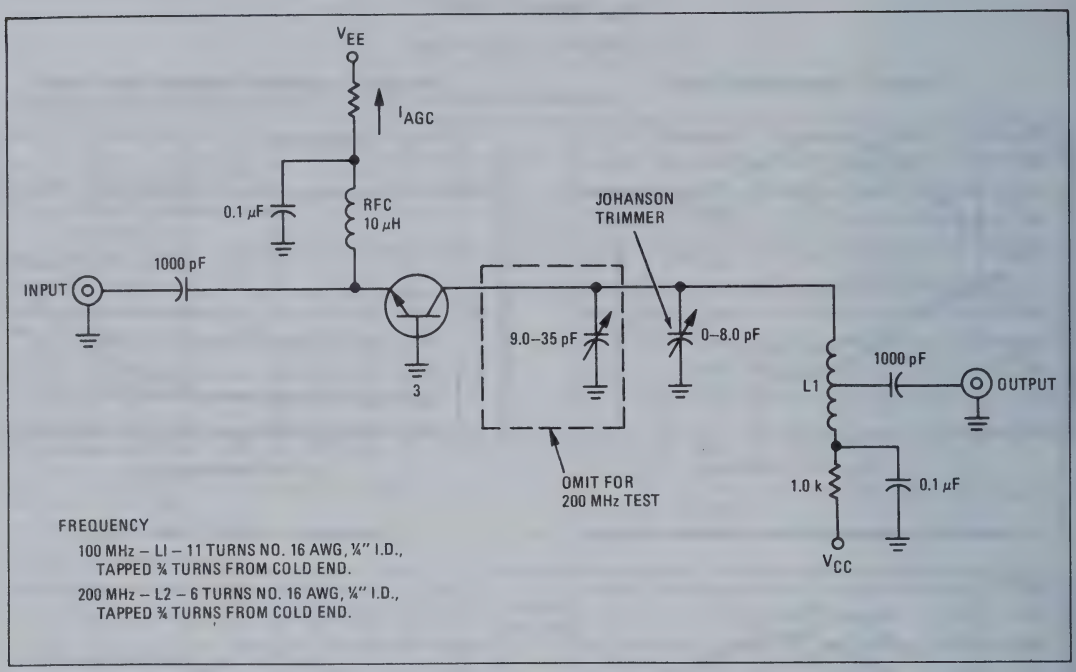


FIGURE 9 – 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER



MPS-H10 (SILICON)
MPS-H11

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for use in VHF/UHF common base oscillator applications.

- High Current-Gain–Bandwidth Product –
  f_T = 650 MHz (Min) @ I_C = 4.0 mAdc
- Low Collector-Base Time Constant –
  $r_b'C_c$ = 9.0 ps (Max) @ I_C = 4.0 mAdc
- Feedback Capacitance –
  C_{rb} = 0.35–0.65 pF – MPS-H10
  0.6–0.9 pF – MPS-H11

NPN SILICON VHF/UHF TRANSISTORS

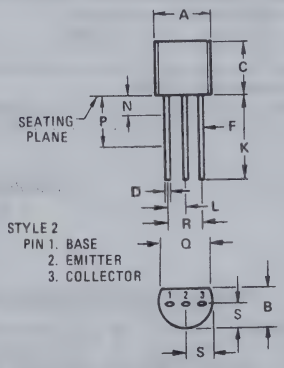


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

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ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	60	–	–
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	650	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	–	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MPS-H10 MPS-H11	C_{rb}	 0.35 0.6	 0.65 0.9	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

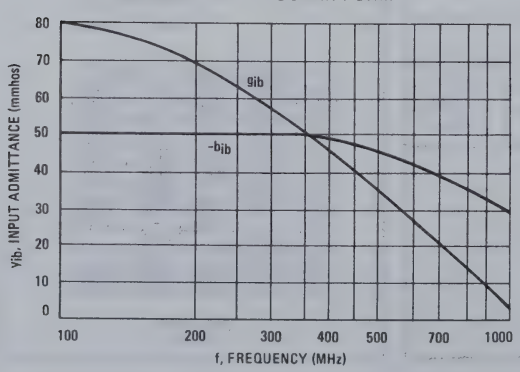
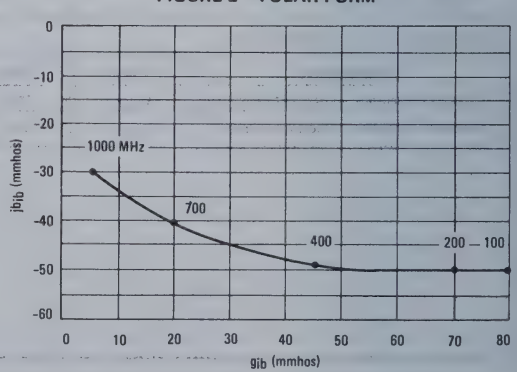


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

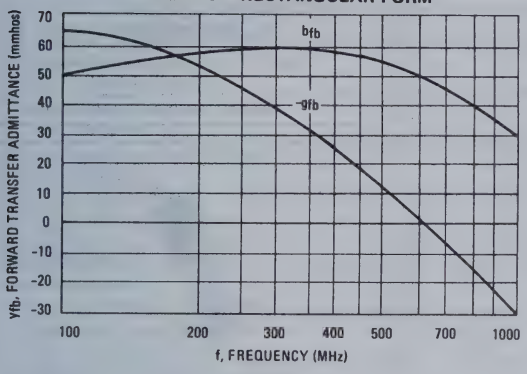
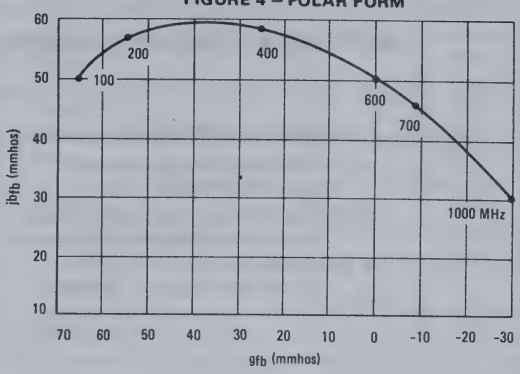


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

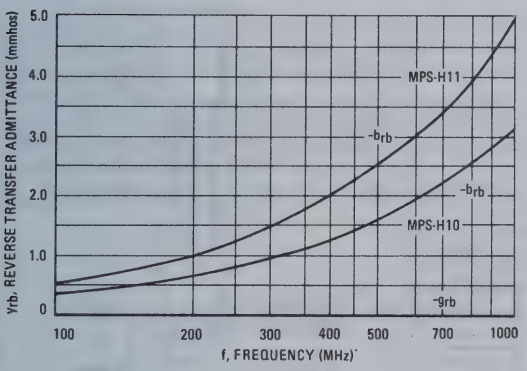
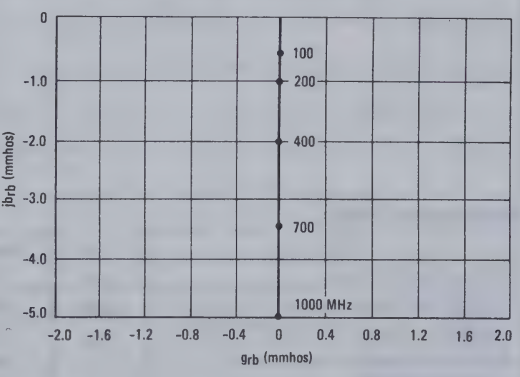


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

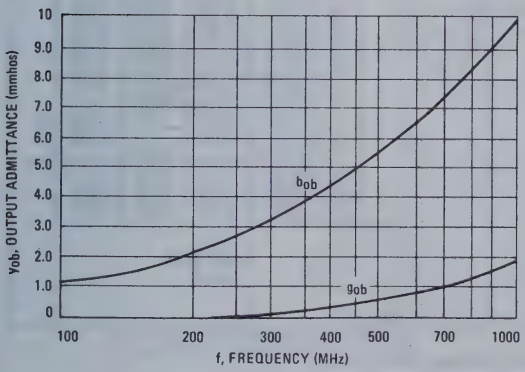
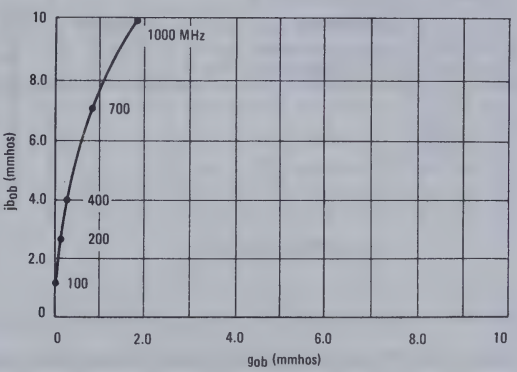


FIGURE 8 – POLAR FORM



MPS-H17 (SILICON)

Advance Information

NPN SILICON ANNULAR TRANSISTORS

. . . designed for CATV converter applications.

- Low Collector-Base Capacitance –
  C_{cb} = 0.9 pF (Max)
- High Current-Gain – Bandwidth Product –
  f_T = 800 MHz (Min) @ I_C = 5.0 mAdc
- Low Noise Figure –
  NF = 6.0 dB (Max) @ f = 200 MHz

NPN SILICON TRANSISTORS

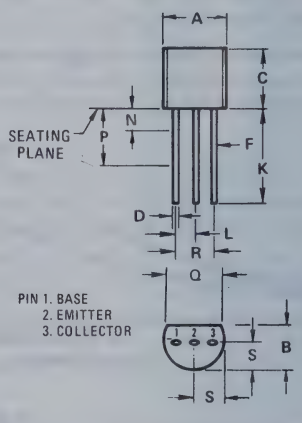


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA}	200	°C/W



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.175	0.205	4.450	5.200
B	0.125	0.165	3.180	4.190
C	0.170	0.210	4.320	5.330
D	0.016	0.021	0.407	0.533
F	0.016	0.019	0.407	0.482
K	0.500	–	12.700	–
L	0.045	0.055	1.150	1.390
N	–	0.050	–	1.270
P	0.250	–	6.350	–
Q	0.135	–	3.430	–
R	0.095	0.105	2.410	2.670
S	0.080	0.105	2.030	2.670

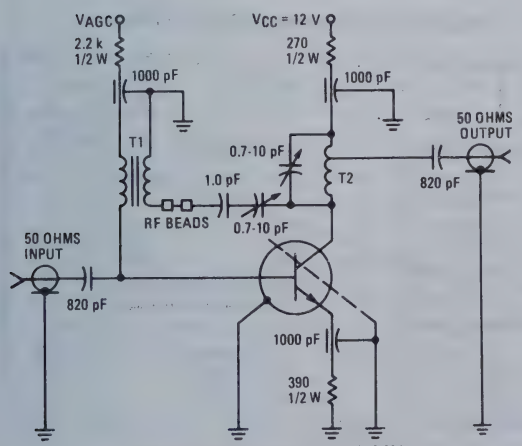
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This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

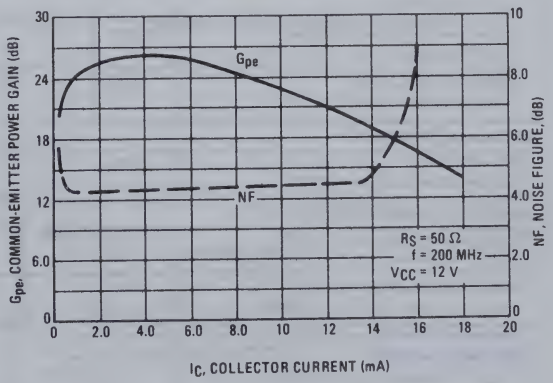
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	–	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	800	–	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	0.3	–	0.9	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	–	–	–
Noise Figure (Figure 1) (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	–	–	6.0	dB
FUNCTIONAL TEST (Figure 2)					
Common-Emitter Amplifier Power Gain (I_C = 5.0 mAdc, V_{CC} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	–	24	–	dB

FIGURE 1 – 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T1 = FERRITE CORE INDIANA GEN. CORP. F-684
T2 = 6 TURNS #16 BUSS WIRE, ID = 1/4", L = 3/4"

FIGURE 2 – TYPICAL COMMON EMITTER POWER GAIN AND NOISE FIGURE



MPS-H19 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain — 15 dB (Min) @ 200 MHz
- Low Collector-Base Capacitance — C_{cb} = 0.65 pF (Max)
- High Current-Gain—Bandwidth Product — f_T = 300 MHz (Min)
- Complete y-Parameters @ 4.0 mA

NPN SILICON VHF TRANSISTOR



MAXIMUM RATINGS

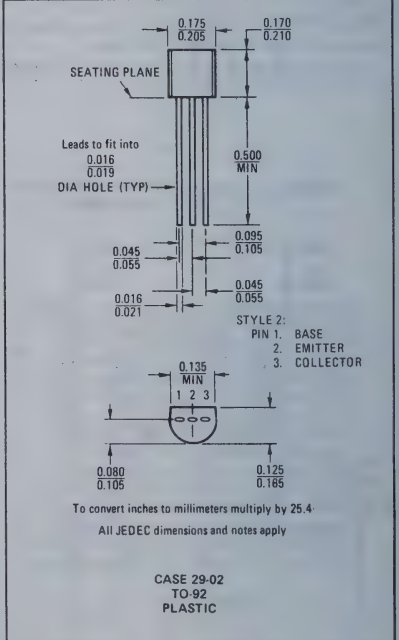
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	45	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	–	MHz
Collector-Base Capacitance (V_{CB = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.65	pF
Conversion Gain (Figures 1 and 2) (213 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)	–	15	–	dB



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

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PLASTIC

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 2)

(f_{sig} = 213 MHz, f_{if} = 45 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN

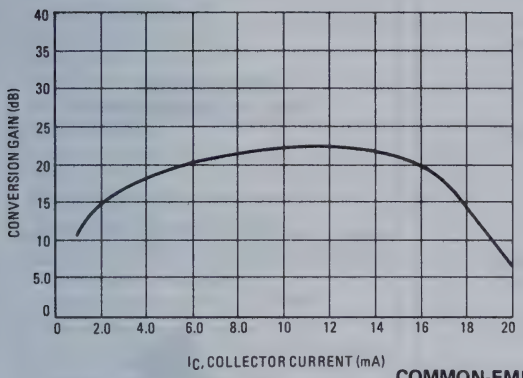
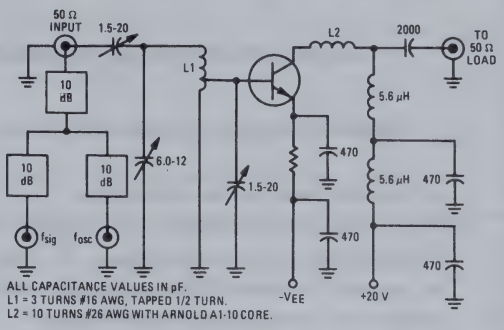


FIGURE 2 – VHF MIXER TEST CIRCUIT



COMMON-EMITTER y PARAMETERS

(V_{CE} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

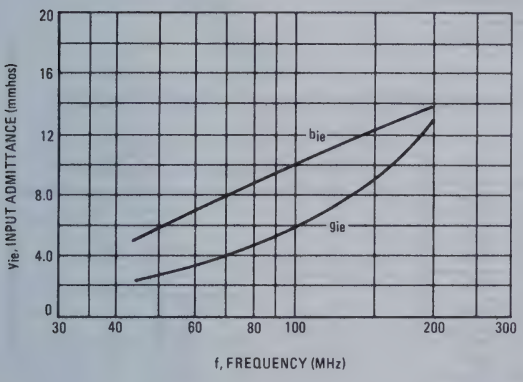


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

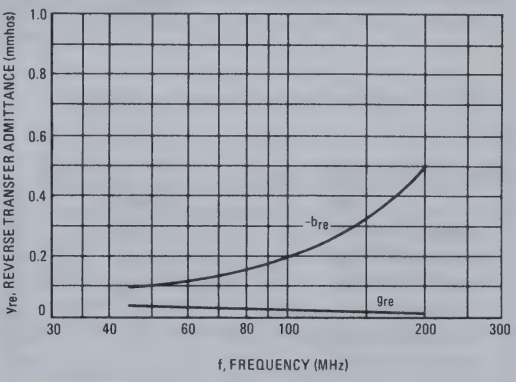


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

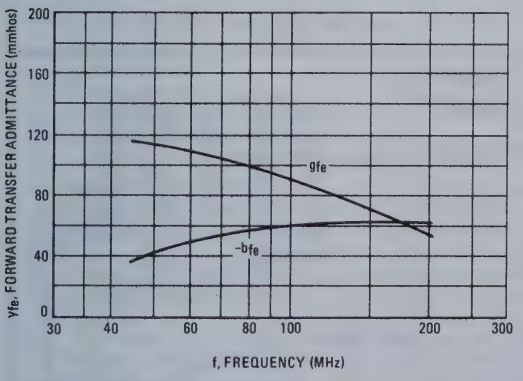
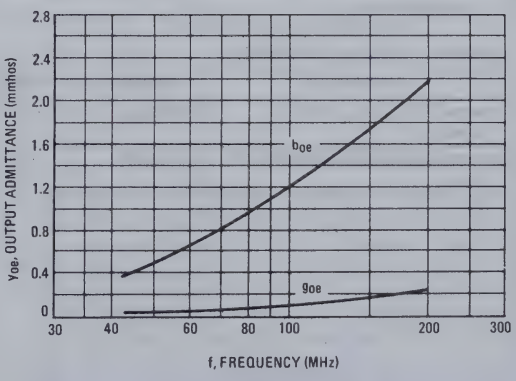


FIGURE 6 – OUTPUT ADMITTANCE



MPS-H20 (SILICON)

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain — 23 dB (Typ)
- Low Collector-Base Capacitance — C_{cb} = 0.65 pF (Max)
- High Current-Gain—Bandwidth Product — f_T = 400 MHz (Min)
- Complete y-Parameter Curves from 50 to 300 MHz
- One-Piece, Injection Molded Unibloc▲ Package

NPN SILICON VHF TRANSISTOR

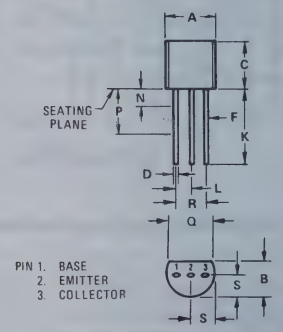


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

▲Trademark of Motorola Inc.

MPS-H20 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	–	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	0.65	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	10	–	ps
Conversion Gain (213 to 45 MHz) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, Oscillator Injection = 200 mVdc, See Figures 1, 2 and 9)	–	18	23	–	dB

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

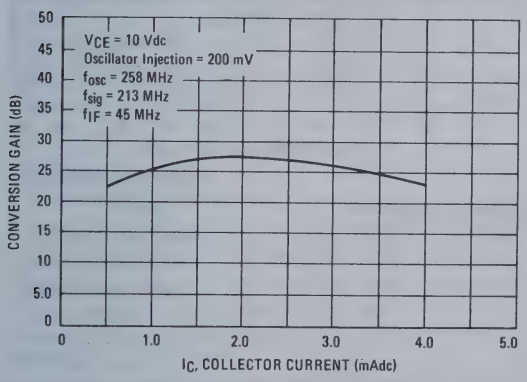
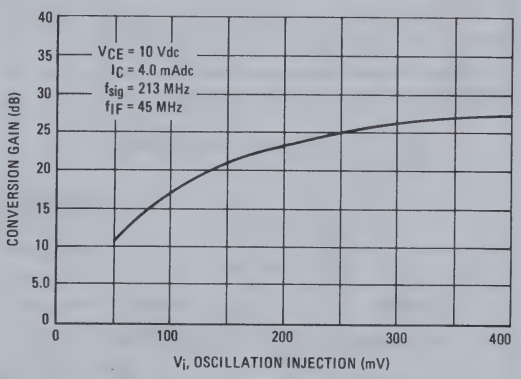


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

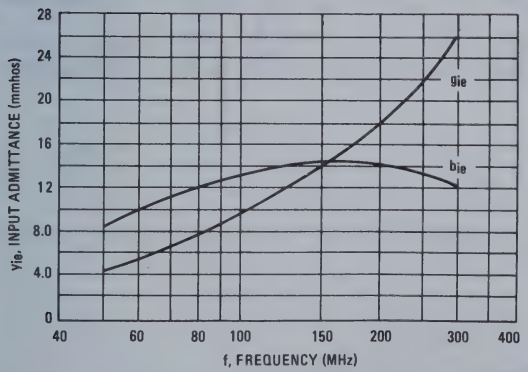
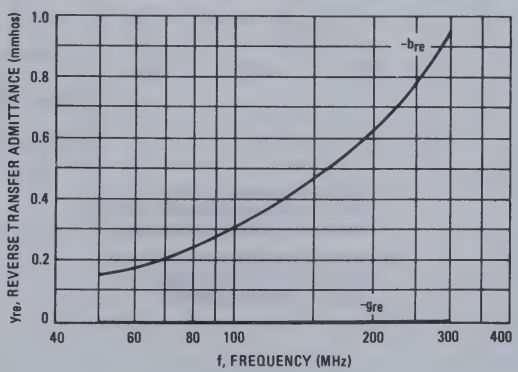


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS

(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

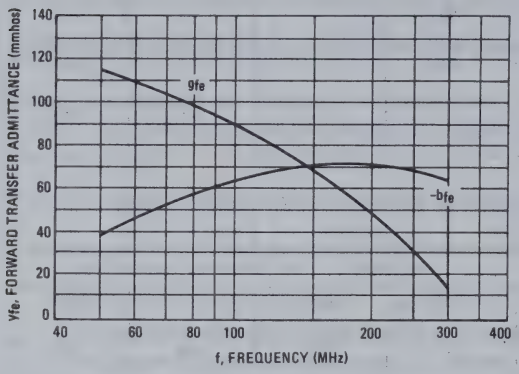


FIGURE 6 – OUTPUT ADMITTANCE

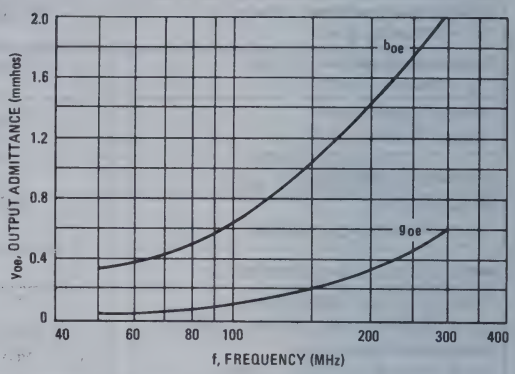


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

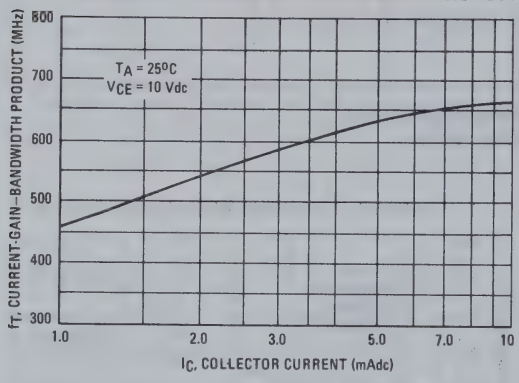


FIGURE 8 – CAPACITANCES

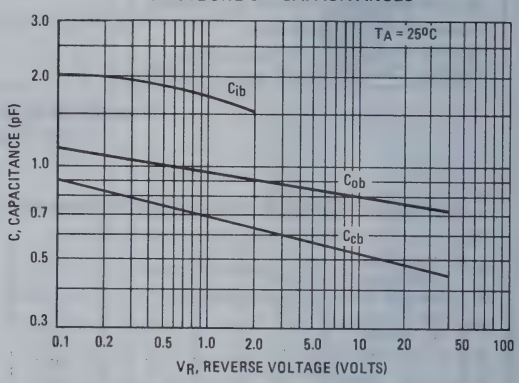
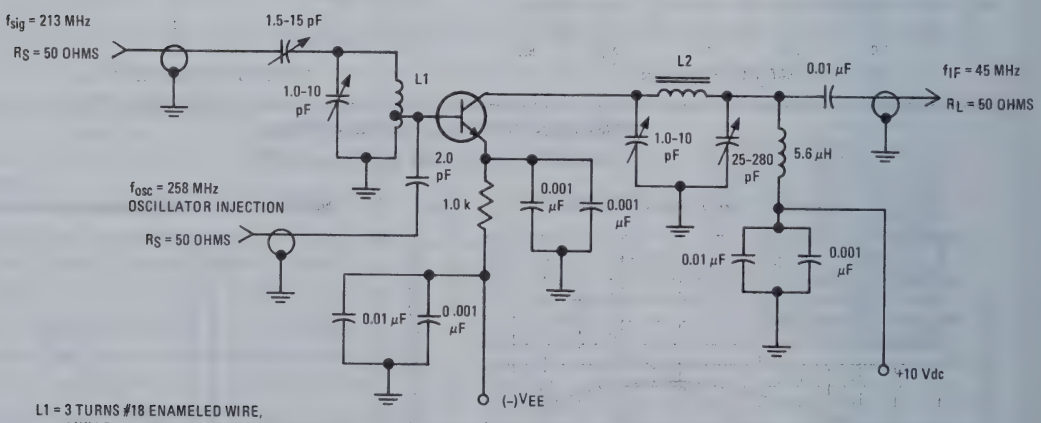


FIGURE 9 – MIXER TEST CIRCUIT



L1 = 3 TURNS #18 ENAMELED WIRE, 1/4" I.D., AIR WOUND, WINDING LENGTH 1/2"; BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND ON 1/4" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPS-H24 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain – 24 dB (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.36 pF (Max)
- High Current-Gain–Bandwidth Product – f_T = 400 MHz (Min)
- Input y-Parameter Curves at 60 and 213 MHz
- Output and Transfer y-Parameters at 45 MHz

NPN SILICON VHF TRANSISTOR



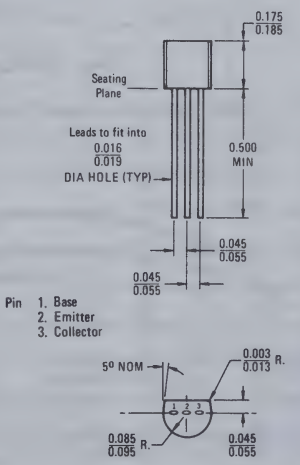
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	220	°C/W

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C – 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C – 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.36	pF
Conversion Gain (Figures 1, 2 and 7)	–				dB
(213 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		19	24	–	
(60 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		24	29	–	

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

(V_{CC} = 20 Vdc, R_S = R_L = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN versus COLLECTOR CURRENT

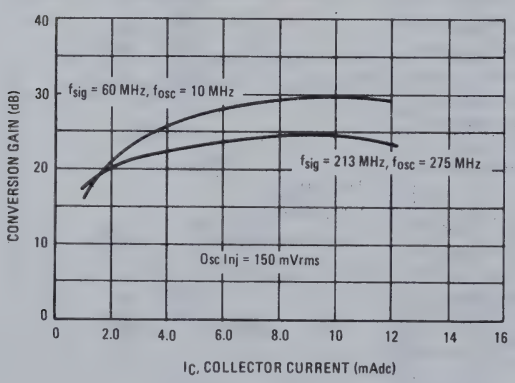
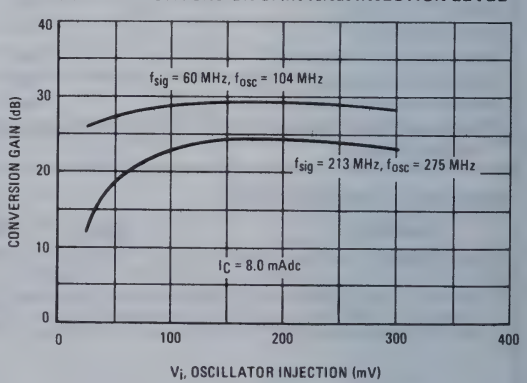


FIGURE 2 – CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

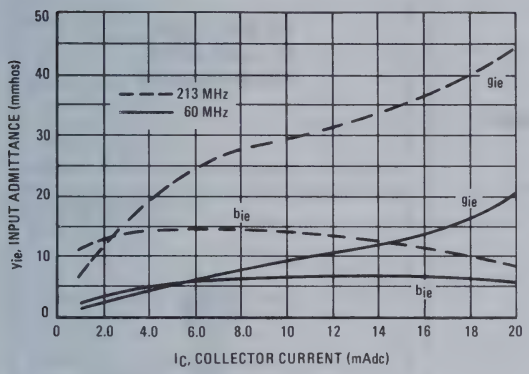


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

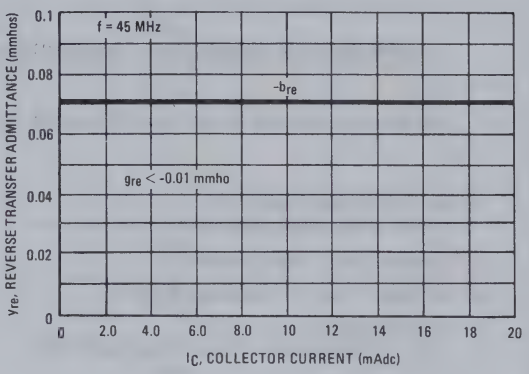


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

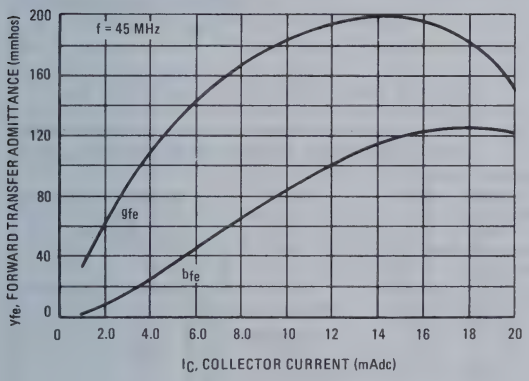


FIGURE 6 – OUTPUT ADMITTANCE

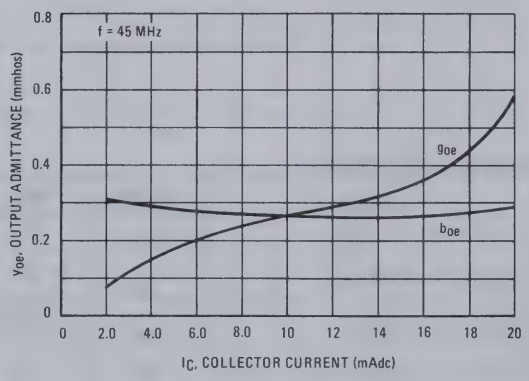
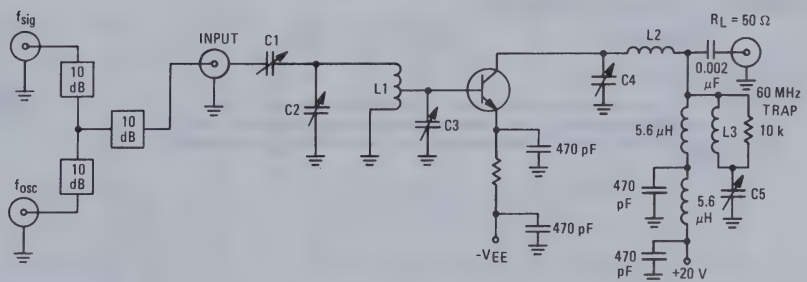


FIGURE 7 – VHF MIXER TEST CIRCUIT
(f_{if} = 44 MHz, B.W. = 6.0 MHz)

f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



MPS-H30 (SILICON)
MPS-H31

NPN SILICON ANNULAR TRANSISTORS

. . . designed for first and second video IF stages in TV receivers.

- Guaranteed Noise Figure —
  NF = 6.0 dB (Max) at 45 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain —
  G_{pe} = 22.5 dB (Min) (Unneutralized) at 45 MHz

NPN SILICON IF AMPLIFIER TRANSISTORS



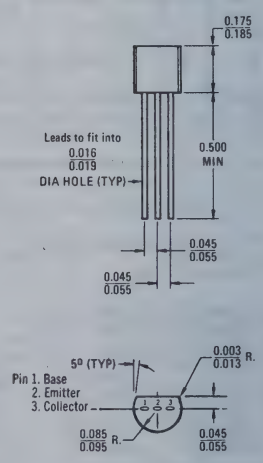
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	-	0.65	pF
Noise Figure (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)	NF	-	6.0	dB
FUNCTIONAL TESTS				
Power Gain (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)	G_{pe}	22.5	31	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 9) MPS-H30 MPS-H31	V_{AGC}	4.4 5.2	5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 9

FIGURE 1 — POWER GAIN

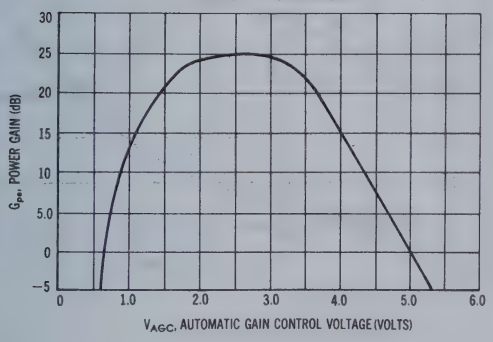
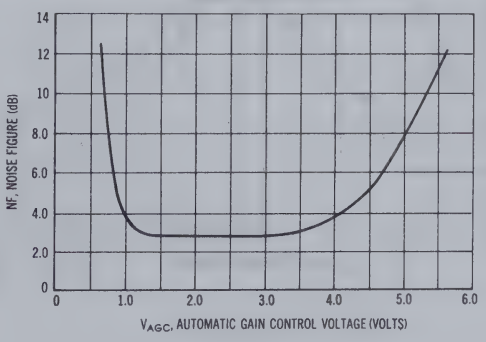


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C, f = 45 MHz

FIGURE 3 — INPUT ADMITTANCE

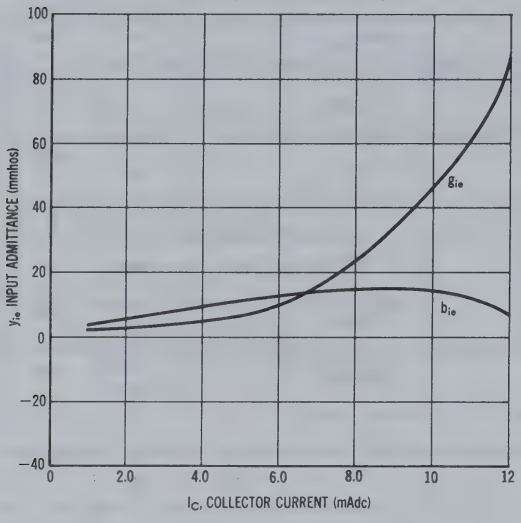


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

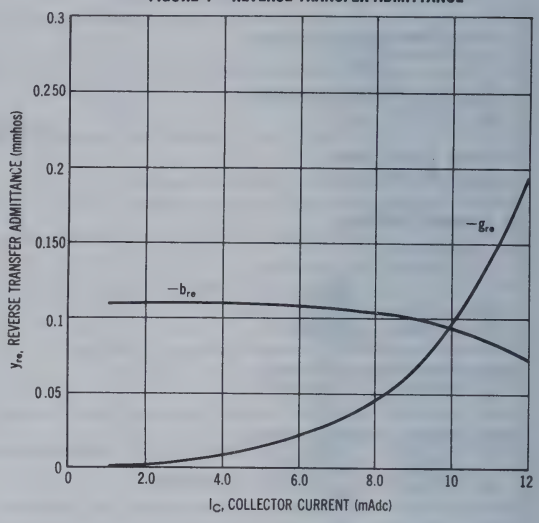


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

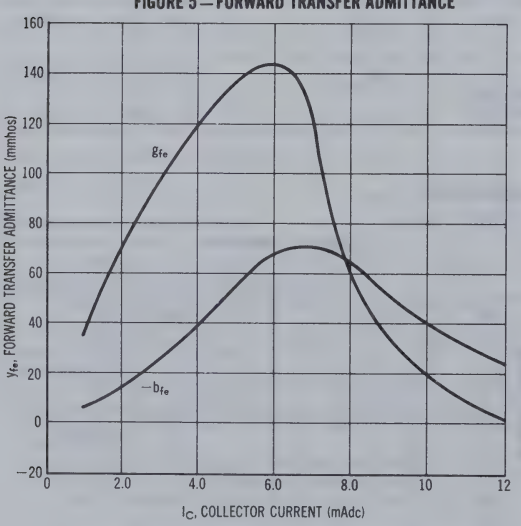


FIGURE 6 — OUTPUT ADMITTANCE

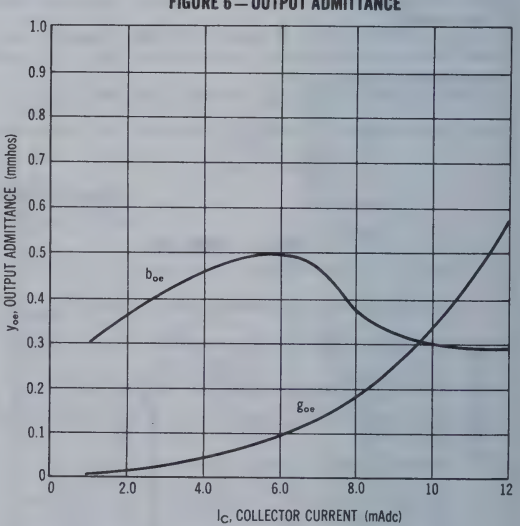


FIGURE 7 — DC CURRENT GAIN

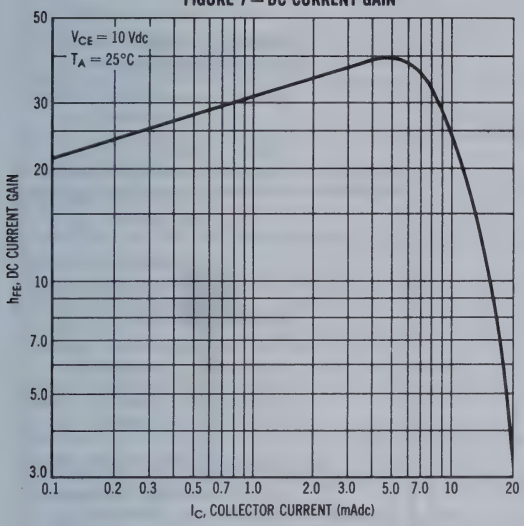


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

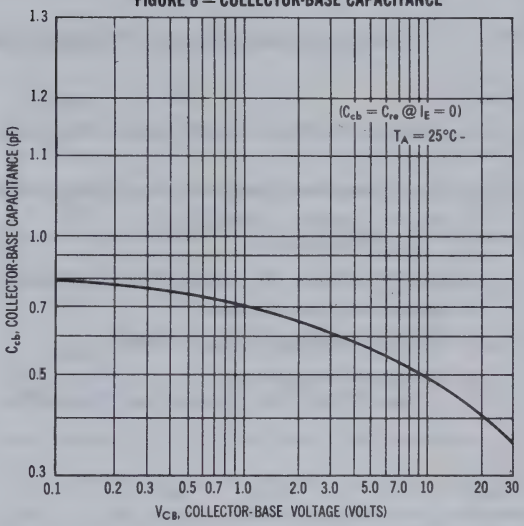
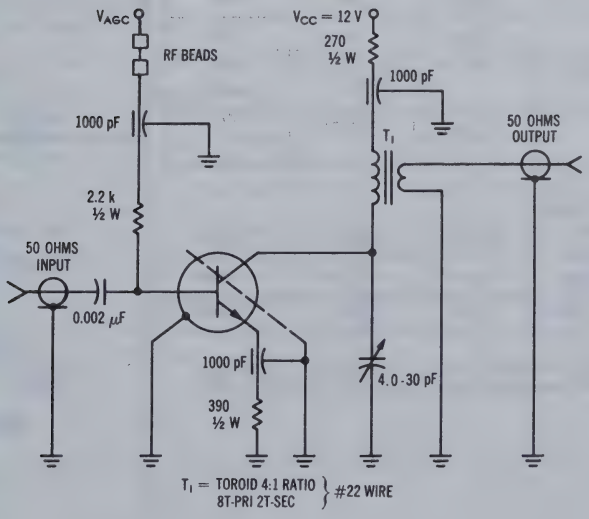


FIGURE 9 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MPS-H32 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for first and second video IF stages in TV receivers.

- Low Collector-Base Capacitance — C_{cb} = 0.22 pF (Max)
- Maximum Unilateralized Power Gain — G_{um} = 44 dB (Typ)
- Low Noise Figure — NF = 3.3 dB (Typ) @ f = 45 MHz
- Forward AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain — G_{pe} = 22.5 dB (Min) (Unneutralized) @ f = 45 MHz

NPN SILICON VHF TRANSISTOR



Shield supplied on request.

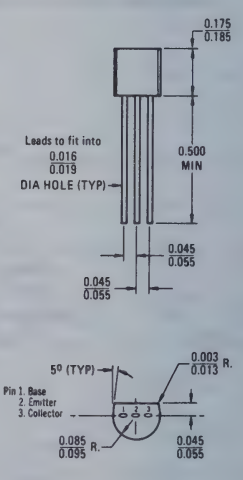
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	27	35	200	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	1.5	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	440	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) (Emitter Guarded)	C_{cb}	–	0.2	0.22	pF
Noise Figure (Figure 10) ($I_E \approx$ 4.0 mAdc, $V_{CE} \approx$ 9.3 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 45 MHz)	NF	–	3.3	–	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 10) ($I_E \approx$ 4.0 mAdc, $V_{CE} \approx$ 9.3 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 45 MHz)	G_{pe}	22.5	25	–	dB
Forward AGC Voltage (Figure 10) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 45 MHz)	V_{AGC}	–	5.5	–	Vdc

SUMMARY-COMMON EMITTER PARAMETERS (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 45 MHz)

Input Conductance	g_{ie}	–	6.0	–	mmhos
Input Capacitance	C_{ie}	–	33	–	pF
Forward Transfer Admittance Magnitude	$\lvert y_{fe} \rvert$	–	110	–	mmhos
Forward Transfer Admittance Phase Angle	$\angle y_{fe}$	–	-22	–	Degrees
Feedback Capacitance	C_{re}	–	0.2	–	pF
Output Conductance	g_{oe}	–	20	–	μmhos
Output Capacitance	C_{oe}	–	1.4	–	pF
Maximum Unilateralized Power Gain $G_{um} = \frac{\lvert y_{fe} \rvert^2}{4\, g_{ie}\, g_{oe}}$	G_{um}	–	44	–	dB

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 10

FIGURE 1 – POWER GAIN

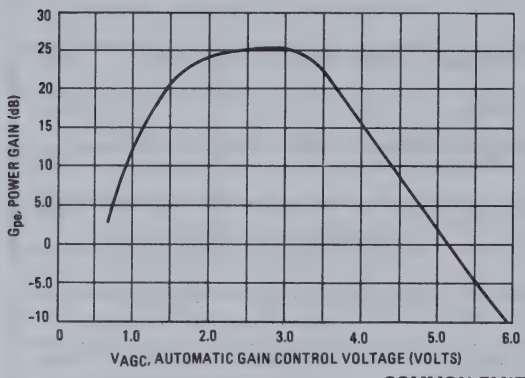
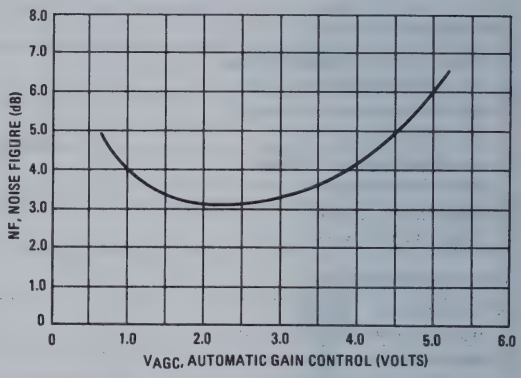


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER PARAMETERS

V_{CE} = 10 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 3 – INPUT ADMITTANCE

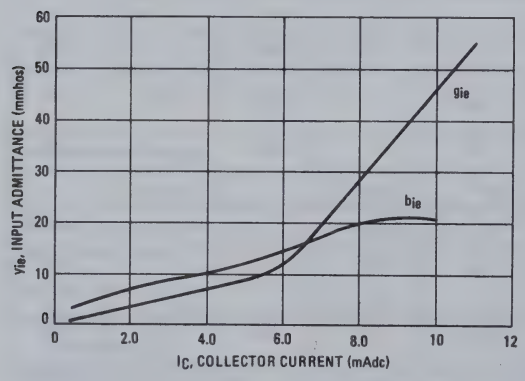


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

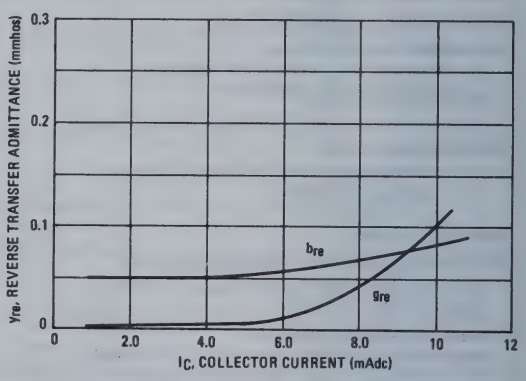


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

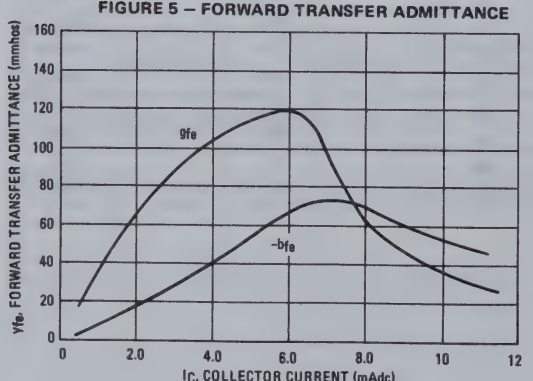


FIGURE 6 – OUTPUT ADMITTANCE

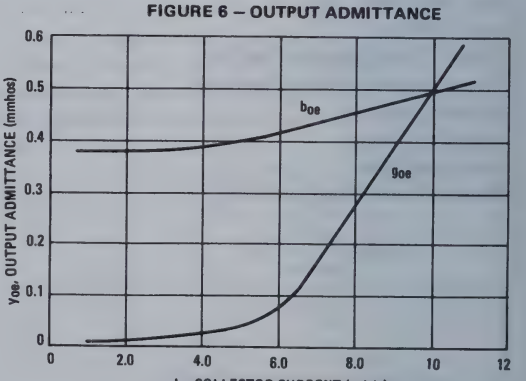


FIGURE 7 – DC CURRENT GAIN

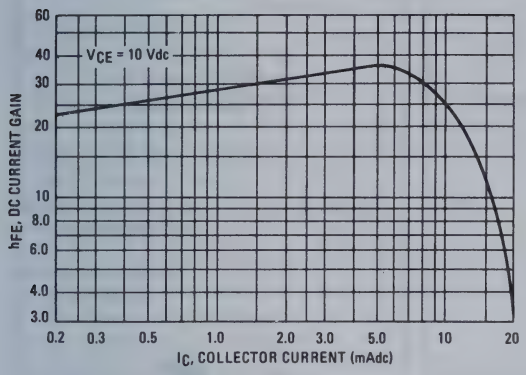


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

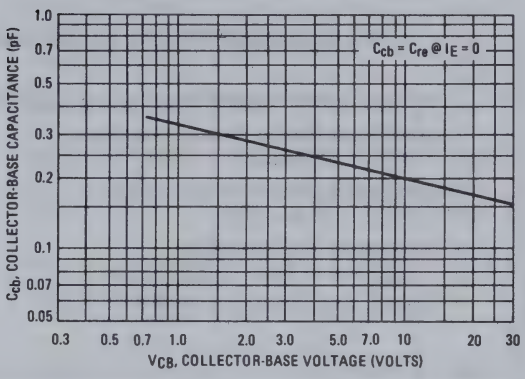


FIGURE 9 – CURRENT-GAIN–BANDWIDTH PRODUCT

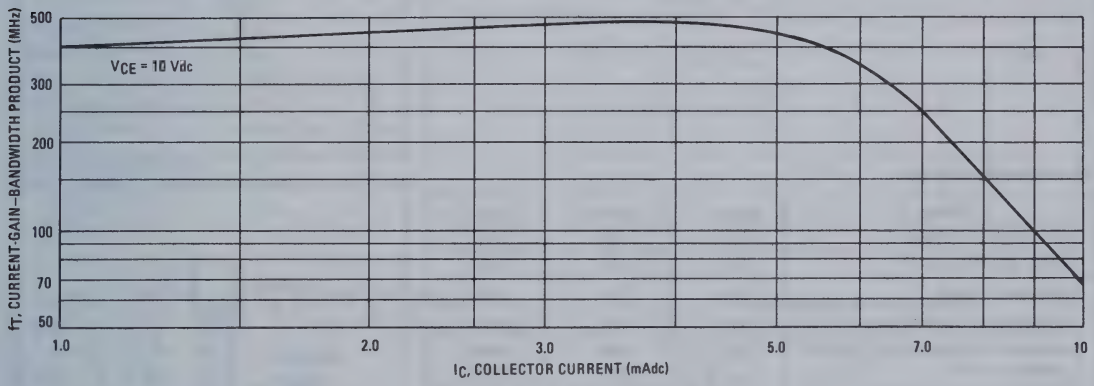
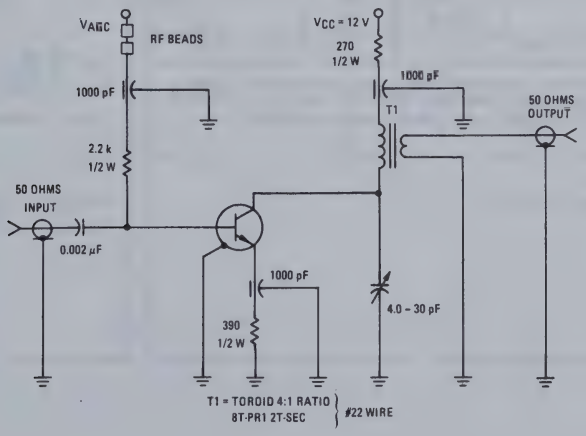


FIGURE 10 – 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MPS-H34 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for third-stage video IF applications in television receivers.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 45 Vdc (Min)
- High Collector-Base Breakdown Voltage — BV_{CBO} = 45 Vdc (Min)
- Low Collector-Base Capacitance — C_{cb} = 0.32 pF (Max) @ V_{CB} = 10 Vdc
- Complete y-Parameter Curves @ 45 MHz

NPN SILICON IF TRANSISTOR



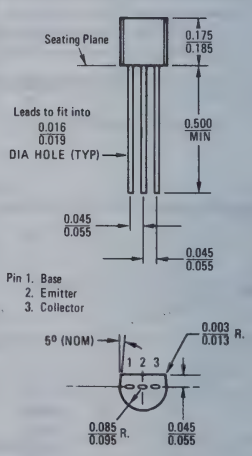
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	220	°C/W

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 15	 – –	 – –	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	–	–	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	–	MHz
Current-Gain – Bandwidth Ratio (I_C = 15 mAdc to I_C = 20 mAdc, V_{CE} = 15 Vdc)	$\frac{f_{T15}}{f_{T20}}$	–	–	1.6	–
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.32	pF

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

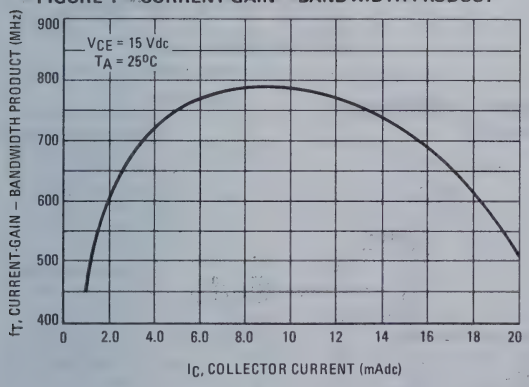
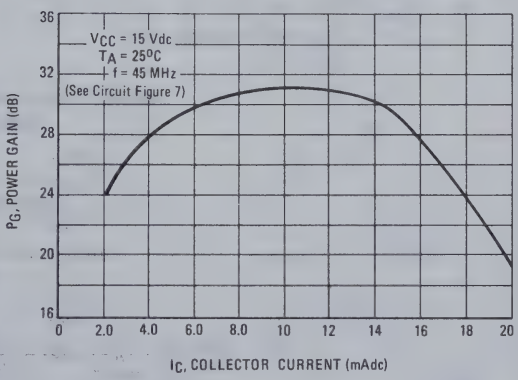


FIGURE 2 – POWER GAIN



COMMON-EMITTER y PARAMETERS
(f = 45 MHz, V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

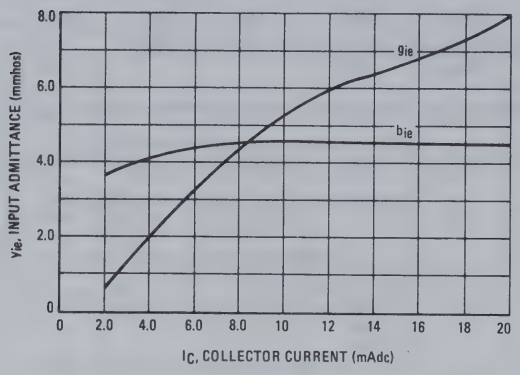


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

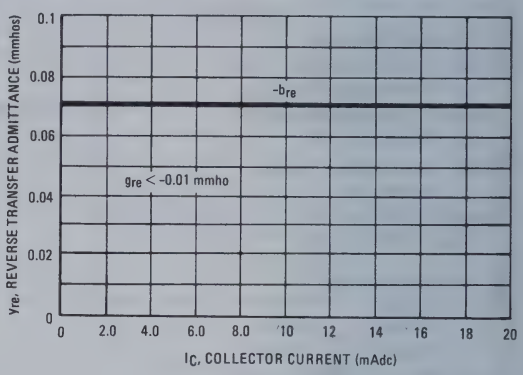


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

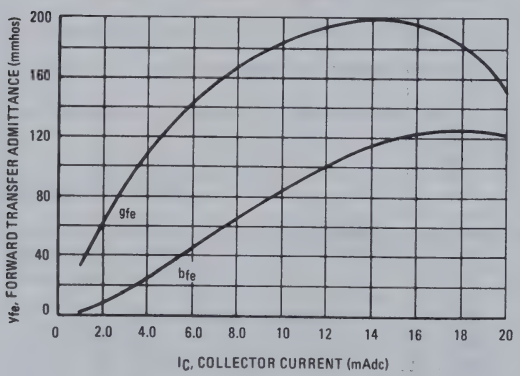


FIGURE 6 – OUTPUT ADMITTANCE

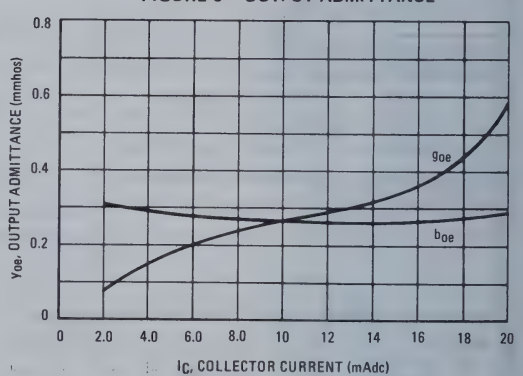
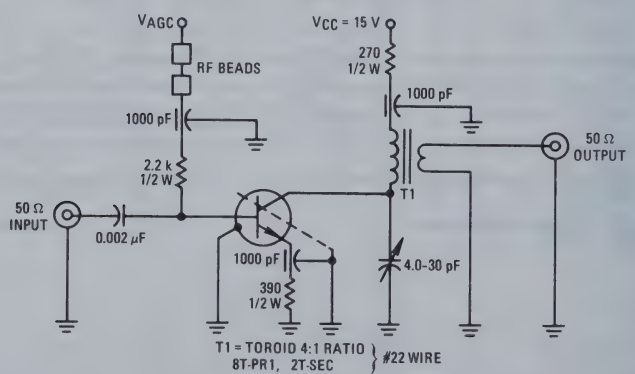


FIGURE 7 – 45 MHz FUNCTIONAL TEST CIRCUIT
(UNNEUTRALIZED)



MPS-H37 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for 4.5 MHz sound IF applications in TV receivers.

- High Breakdown Voltage —
  BV_{CEO} = 40 V (Min) @ I_C = 1.0 mAdc
- High Output Resistance @ 4.5 MHz —
  R_{oep} = 100 k Ohms (Min) @ I_C = 2.0 mAdc
- Low Reverse Feedback Capacitance —
  C_{re} = 0.7 pF (Max) @ V_{CB} = 10 Vdc
- Complete y-Parameter Curves @ 4.5 MHz

NPN SILICON IF AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

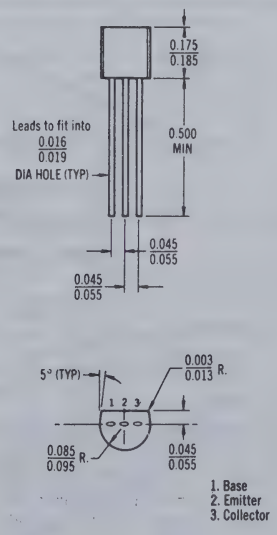
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EE}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{re}	—	0.7	pF
Output Resistance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 4.5 MHz)	R_{oep}	100	—	k ohms



CASE 29 (2)
TO-92

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C — 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

COMMON-EMITTER y PARAMETERS

f = 4.5 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

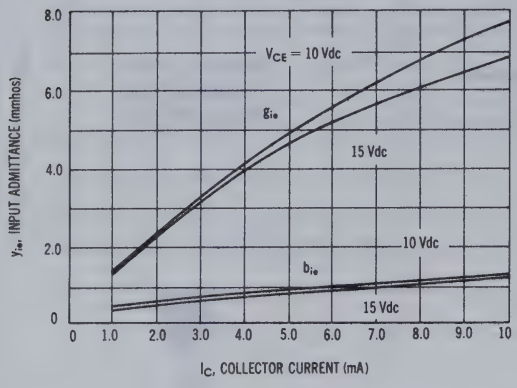


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

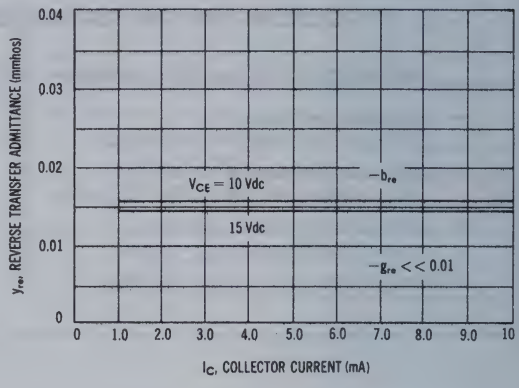


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

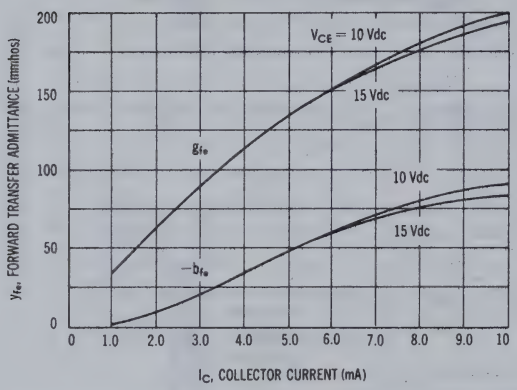


FIGURE 4 — OUTPUT ADMITTANCE

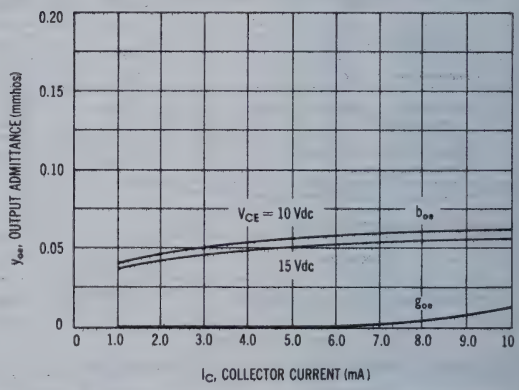


FIGURE 5 — CAPACITANCES

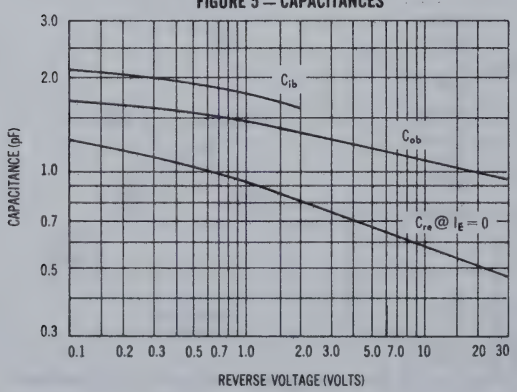
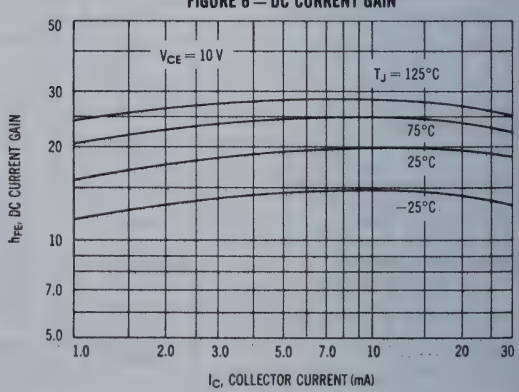


FIGURE 6 — DC CURRENT GAIN



MPS-H54 (SILICON)
MPS-H55

PNP SILICON ANNULAR TRANSISTORS

. . . MPS-H54 is designed for RF amplifier applications in AM receivers.
. . . MPS-H55 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage – BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance – C_{cb} = 1.0 pF (Typ)
- Low Output Admittance – h_{oe} = 10 μmhos (Max)
- Low Noise Figure – NF = 2.0 dB (Max) – MPS-H54
- Complement to NPN MPS-H04, MPS-H05

PNP SILICON TRANSISTORS



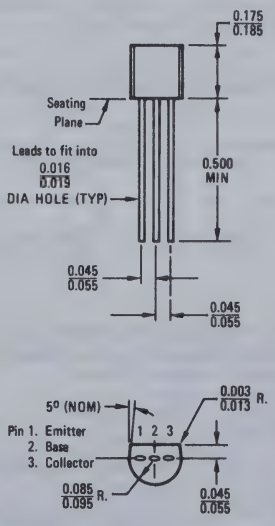
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg} (1)	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA} (1)	0.367	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

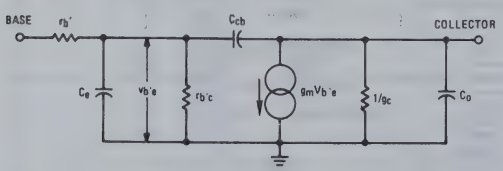


CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc)	MPS-H54 MPS-H55	h_{FE}	 30 30	 70 70	 120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.16	0.25	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	80	185	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{cb}	–	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	6.0	15	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz)	MPS-H54	NF	–	1.5	2.0	dB

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_b' \approx$ 15 Ohms

r_e = 26 mV/I_E

$$C_e = \frac{1}{2\pi f_t r_e}$$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 3 and 6)

C_o = 0.2 pF

$r_{b'c} = (h_{fe} + 1)\, r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_b' + r_{b'c}$

$h_{fe} \approx 1.1\, h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega\,(C_e + C_{cb})\, r_{b'c}}{(r_b' + r_{b'c}) + j\omega\,(C_e + C_{cb})\, r_b'\, r_{b'c}}$$

$$y_{12} = \frac{j\omega\, C_{cb}}{j\omega\,(C_{cb} + C_e)\, r_b' + \dfrac{r_b' + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m \left(\frac{1}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_b'} \right) - \frac{j\omega\, C_{cb}}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_b'}$$

$$y_{22} = g_c + jwCo - g_m r_b' y_{12} + \frac{\left(\dfrac{r_b' + r_{b'c}}{r_b' r_{b'c}} + j\omega\, C_e\right)\left(j\omega\, C_{cb}\right)}{\left(\dfrac{r_b' + r_{b'c}}{r_b' r_{b'c}} + j\omega\,(C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

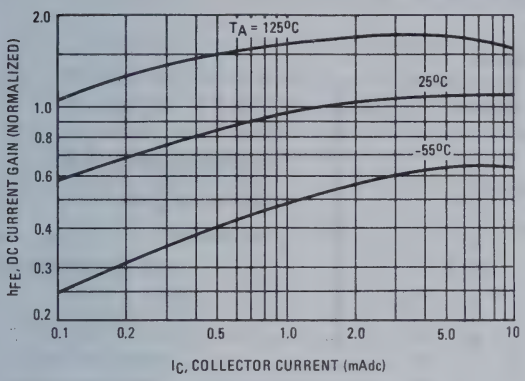


FIGURE 3 – "ON" VOLTAGES

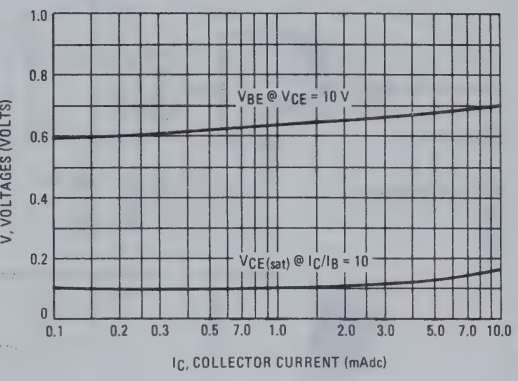


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

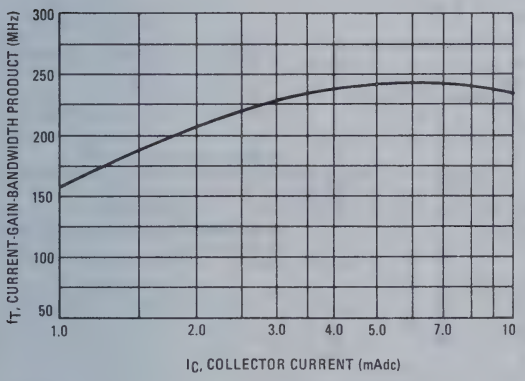


FIGURE 5 – COLLECTOR-BASE CAPACITANCE

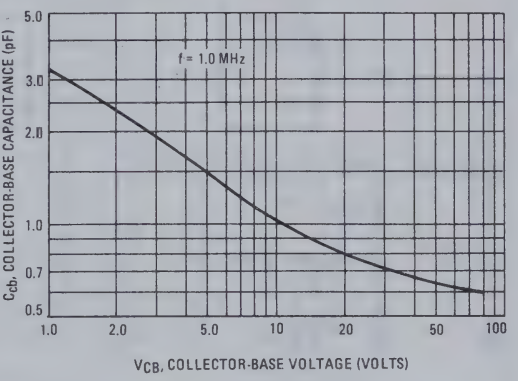


FIGURE 6 – OUTPUT ADMITTANCE

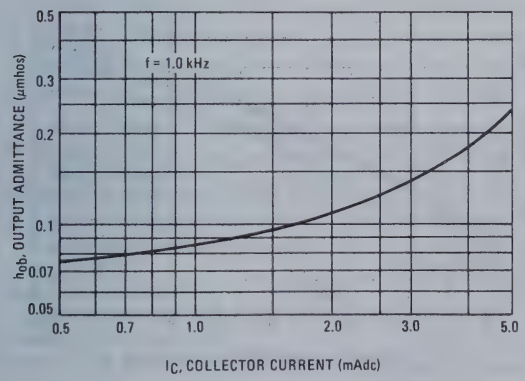
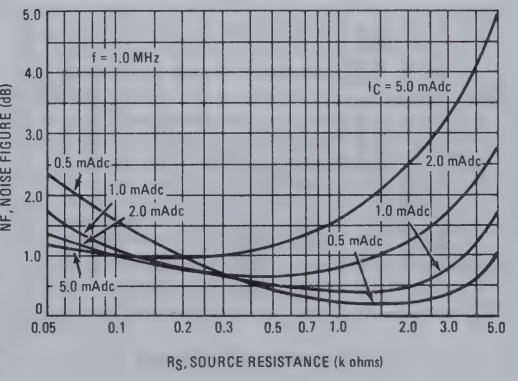


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT

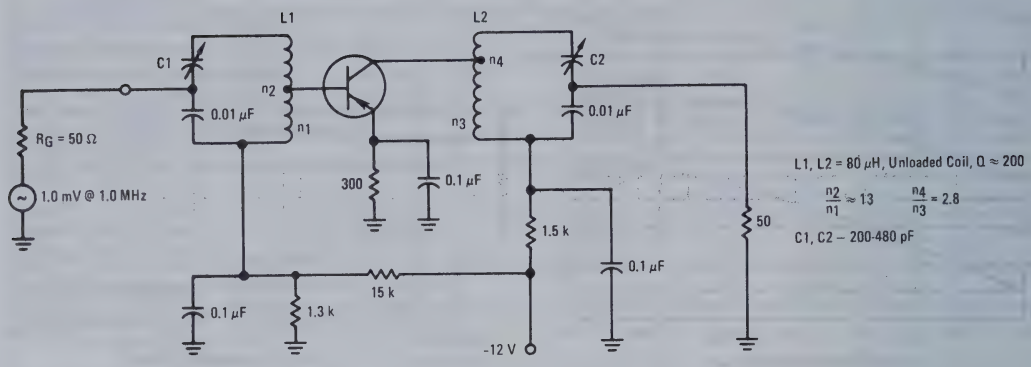


FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT

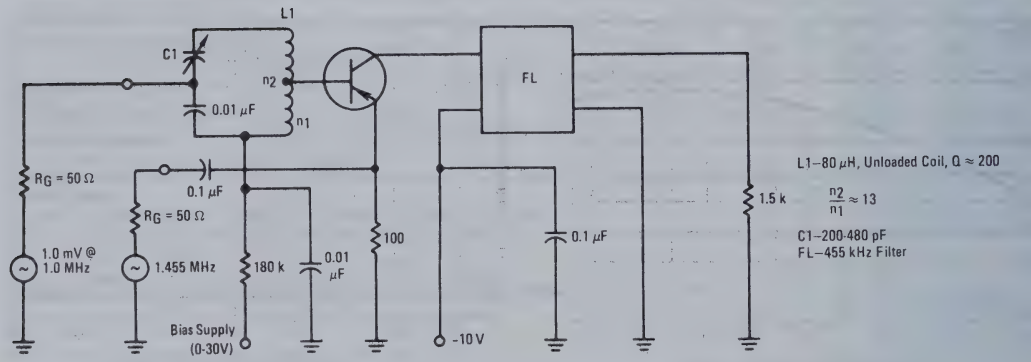


FIGURE 10 – AMPLIFIER POWER GAIN

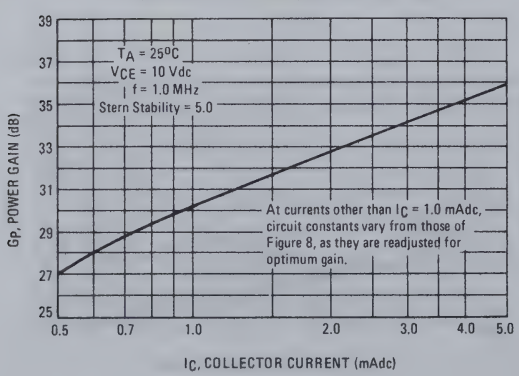
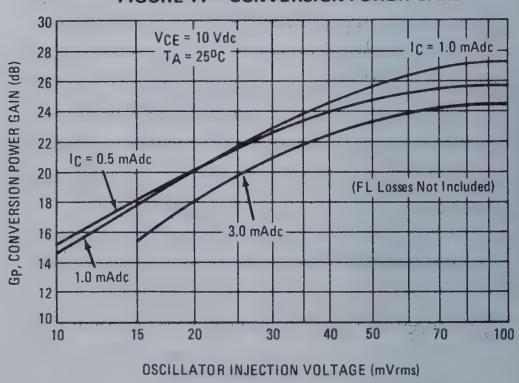


FIGURE 11 – CONVERSION POWER GAIN



MPS-H81 (SILICON)

PNP SILICON EPITAXIAL TRANSISTOR

. . . designed for use in UHF/VHF oscillator applications.

- Complete y-Parameter Curves
- Low Collector-Emitter Capacitance –
  C_{ce} = 0.65 pF (Max) @ V_{CB} = 10 Vdc
- High Current Gain – Bandwidth Product – @ I_C = 5.0 mAdc
  f_T = 600 MHz (Min)
  = 1250 MHz (Typ)

PNP SILICON TRANSISTOR



MAXIMUM RATINGS

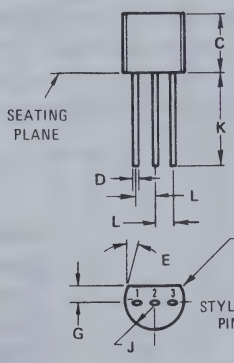
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	–	–	–
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1250	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	–	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ce}	–	–	0.65	pF



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
C	0.175	0.185	4.450	4.700
D	0.016	0.019	0.407	0.482
E	5° NOM		5° NOM	
G	0.045	0.055	1.150	1.390
J	0.085	0.095	2.160	2.420
K	0.500	–	12.700	–
L	0.050 TP		1.270 TP	
M	0.003	0.013	0.076	0.330

CASE 29-01
TO-92

TYPICAL COMMON-BASE y-PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

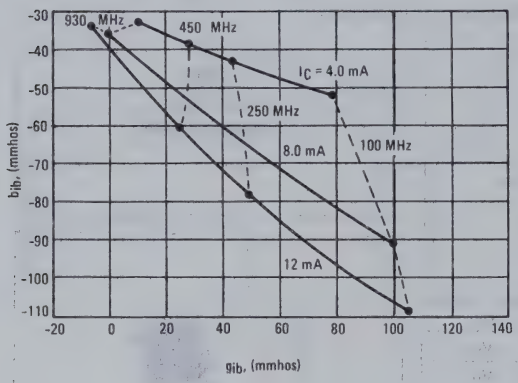


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

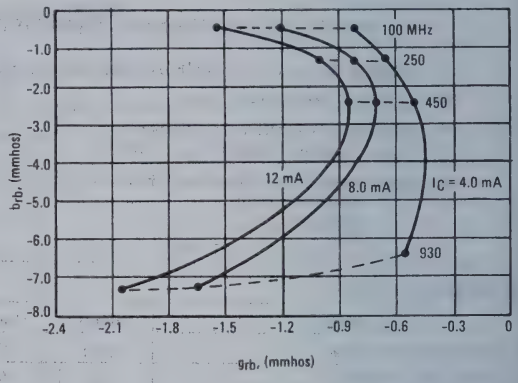


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

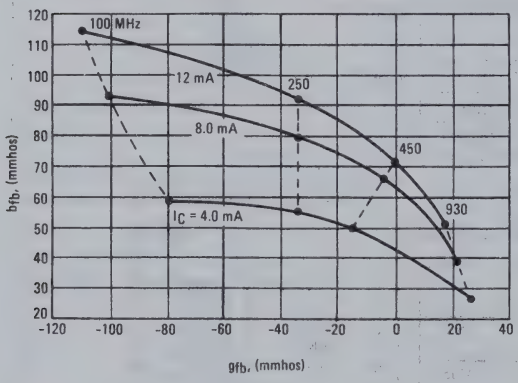


FIGURE 4 – OUTPUT ADMITTANCE

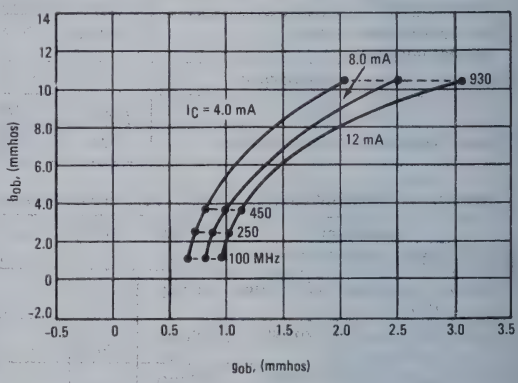
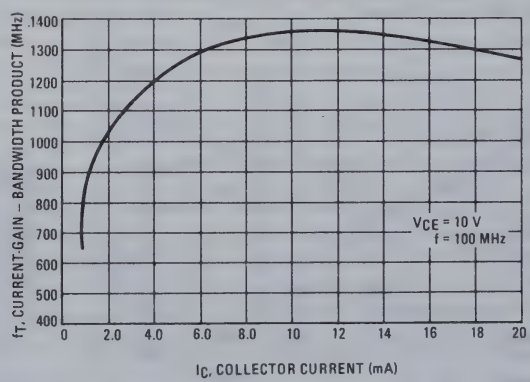


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



MPS-H83 (SILICON)

PNP SILICON ANNULAR TRANSISTORS

. . . designed for common-base UHF RF amplifier applications.

- Guaranteed Noise Figure — NF = 4.2 dB (Typ) @ f = 850 MHz
- Guaranteed Forward AGC Characteristics
- Complete y-Parameter Curves from 400 MHz to 900 MHz
- Guaranteed Power Gain — G_{pb} = 16 dB (Typ) @ f = 850 MHz
- Low Feedback Capacitance Allowing Stable Unneutralized Operation — C_{ce} = 0.3 pF (Max)

PNP SILICON UHF TRANSISTORS



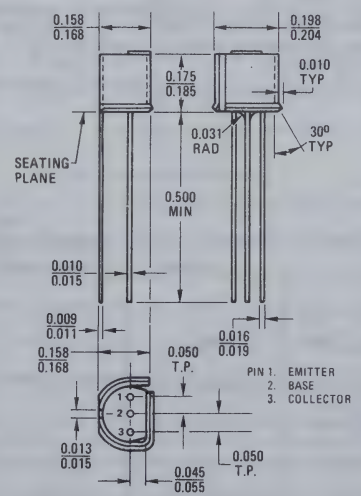
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



To convert inches to millimeters multiply by 25.4

CASE 29A
PLASTIC TRANSISTOR
WITH SHIELD

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	950	–	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)	C_{ce} (C_{rb})	–	–	0.3	pF
Noise Figure (Figure 9) (I_C = 2.5 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 850 MHz)	NF	–	4.2	6.5	dB
FUNCTIONAL TEST (Using shield as shown in dimensional information)					
Common-Base Amplifier Power-Gain (Figure 9) (I_C = 2.5 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms f = 850 MHz)	G_{pb}	10	16	–	dB
Forward AGC Current (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 850 MHz)	I_{AGC}	4.5	5.6	7.5	mAdc

AGC CHARACTERISTICS

V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 850 MHz, Data from Figure 9 represents device shielded similar to that shown in outline dimensions.

FIGURE 1 – POWER GAIN

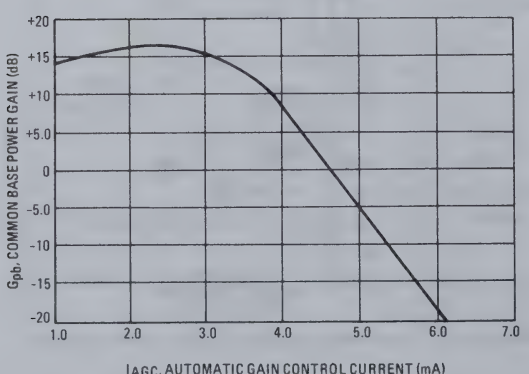
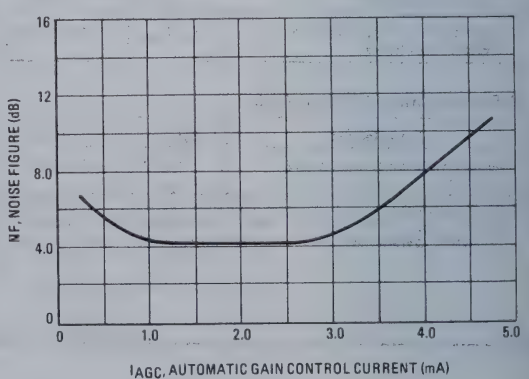


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 3 – INPUT ADMITTANCE

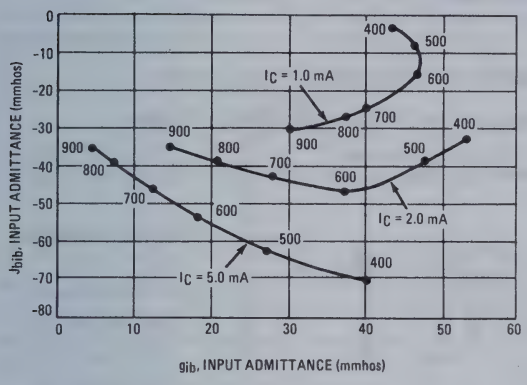


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

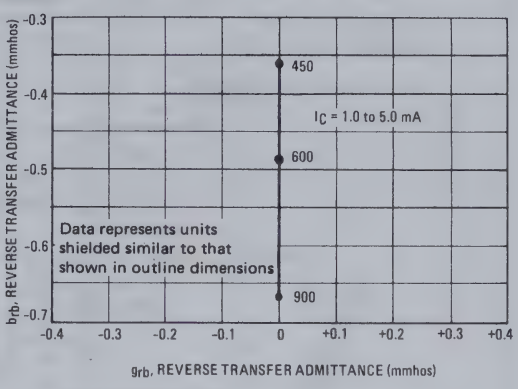


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

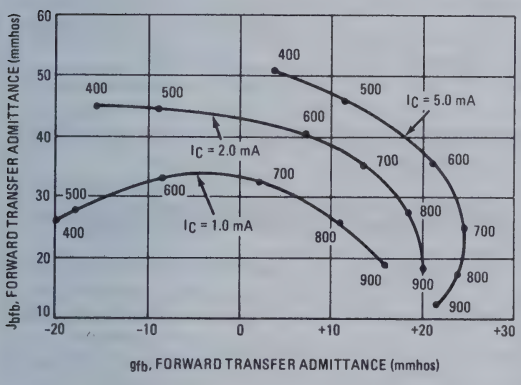


FIGURE 6 – OUTPUT ADMITTANCE

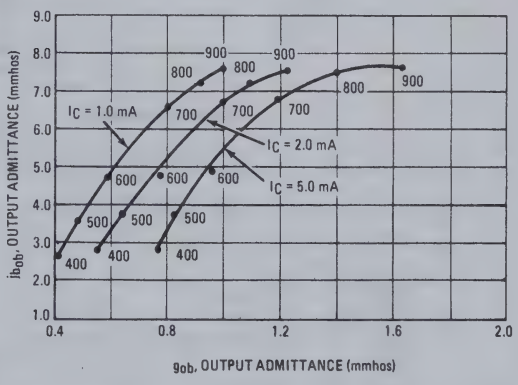


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

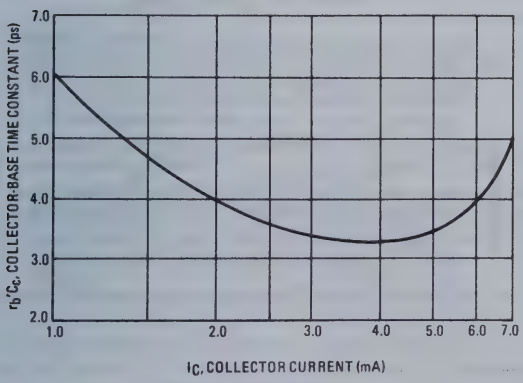


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

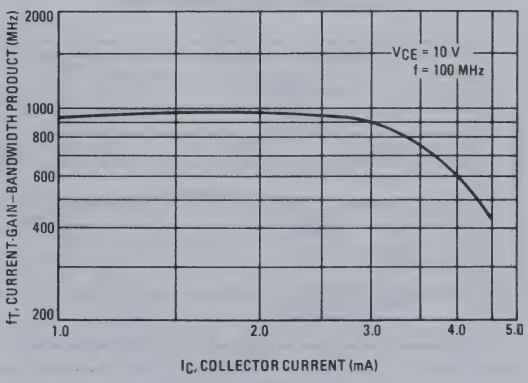
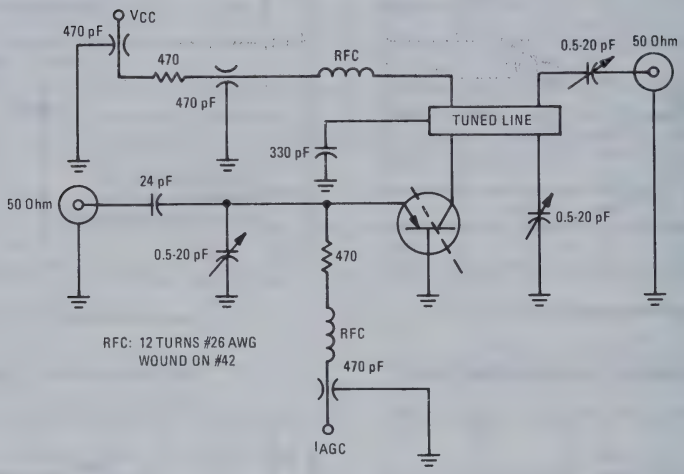


FIGURE 9 – 850 MHz POWER GAIN AND NOISE FIGURE TEST FIXTURE



S FROM y PARAMETERS

$$S_{11} = \frac{(1-y_{11})(1+y_{22}) + y_{12}y_{21}}{D}$$

$$S_{22} = \frac{(1+y_{11})(1-y_{22}) + y_{21}y_{12}}{D}$$

$$S_{12} = \frac{-2y_{12}}{D}$$

$$S_{21} = \frac{-2y_{21}}{D}$$

Where $D = (1+y_{11})(1+y_{22}) - (y_{12}y_{21})$

In converting from y to S parameters, the y parameters must first be multiplied by Z_o, and then substituted in the equations for conversion to S parameters.

FIGURE 10 – DC CURRENT GAIN

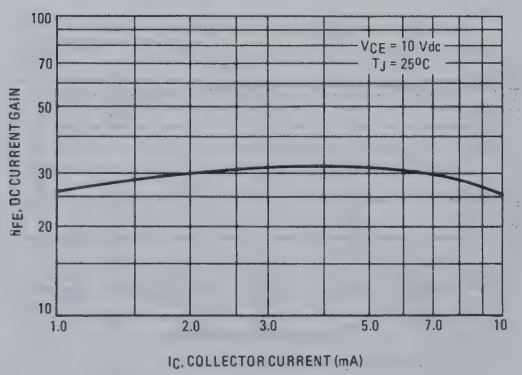
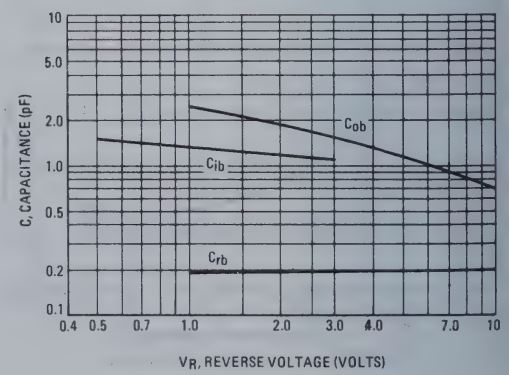


FIGURE 11 – CAPACITANCES



MPS-H85 (SILICON)

Advance Information

PNP SILICON ANNULAR TRANSISTOR

. . . designed for common base VHF RF amplifier applications.

PNP SILICON VHF TRANSISTOR

G_{pb} @ 200 MHz > 14 dB



MAXIMUM RATINGS

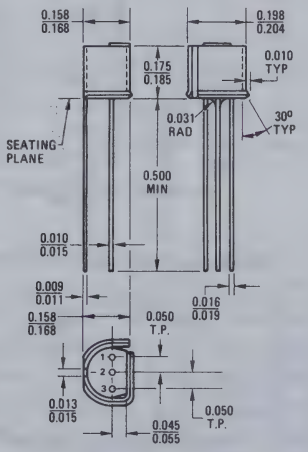
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted).

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	–	–
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	–	MHz
Collector-Emitter Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ce}	–	0.2	pF
Noise Figure (Figure 6) (I_C = 2.5 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	NF	–	6.5	dB
FUNCTIONAL TEST (Using shield as shown in dimensioned information).				
Common-Emitter Amplifier Power Gain (I_C = 2.5 mAdc, V_{CC} = 20 Vdc, f = 200 MHz) (Figure 6)	G_{pb}	14	–	dB



PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 29A
PLASTIC TRANSISTOR
WITH SHIELD

This is advance information on a new introduction and specifications are subject to change without notice.

COMMON BASE y PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

Data represents units shielded similar to that shown in outline dimensions.

FIGURE 1 – INPUT ADMITTANCE

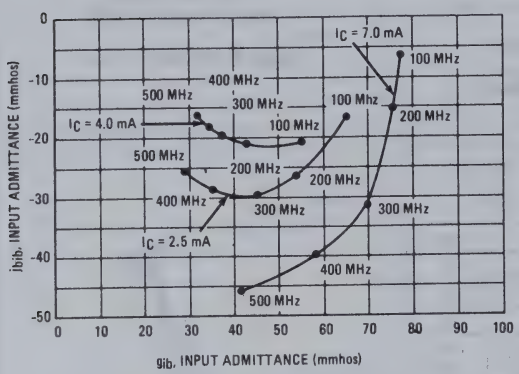


FIGURE 2 – FORWARD TRANSFER ADMITTANCE

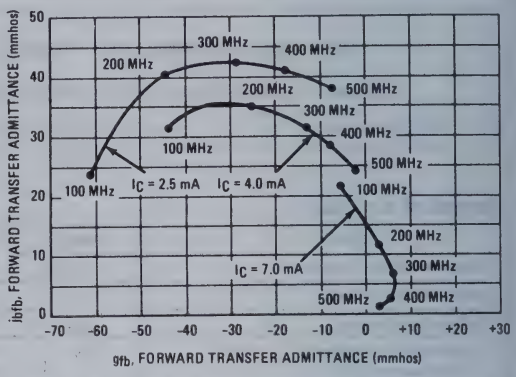


FIGURE 3 – REVERSE TRANSFER ADMITTANCE

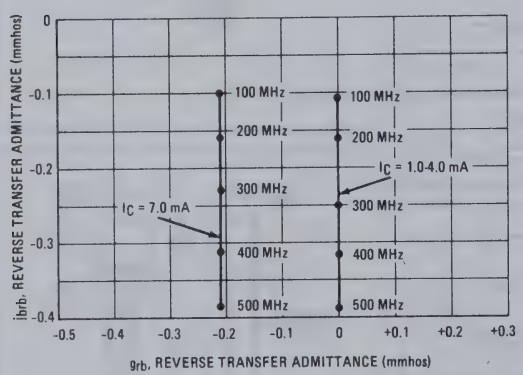
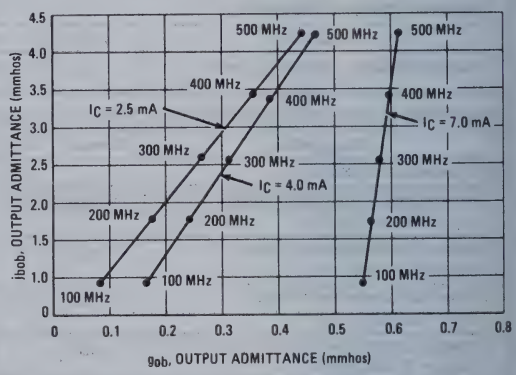


FIGURE 4 – OUTPUT ADMITTANCE



AGC CHARACTERISTICS

FIGURE 5 – POWER GAIN AND NOISE FIGURE

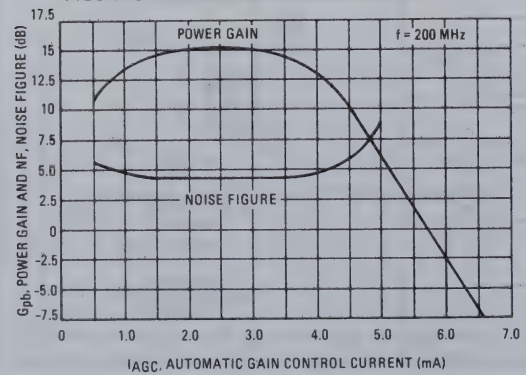
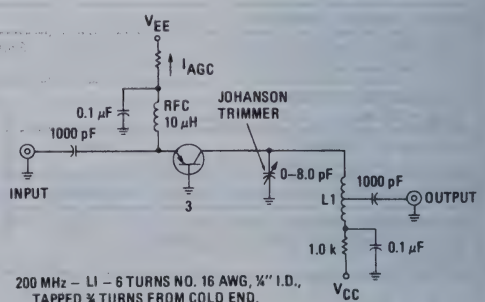


FIGURE 6 – AGC TEST CIRCUIT



200 MHz – L1 – 6 TURNS NO. 16 AWG, ¼" I.D., TAPPED ¾ TURNS FROM COLD END.

MPS-L01 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages —
  BV_{CEO} = 120 Vdc (Min), BV_{CBO} = 140 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (max) @ I_C = 50 mA
- One-Piece, Injection-Molded Unibloc Package for High Reliability

HIGH VOLTAGE

NPN SILICON AMPLIFIER TRANSISTOR



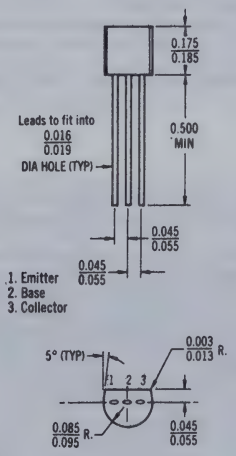
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



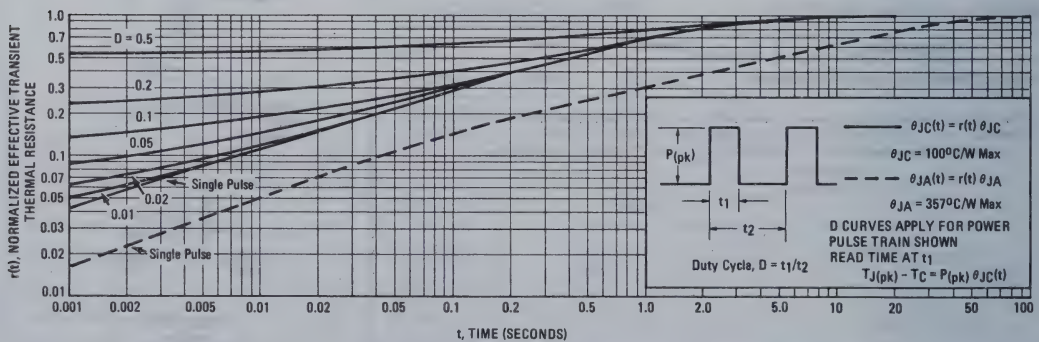
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}*	120	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}*	50	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.20	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	0.30	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.2	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	1.4	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	–	–

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS
(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

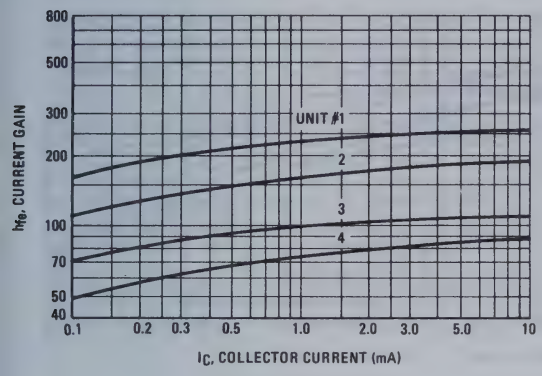


FIGURE 3 – OUTPUT ADMITTANCE

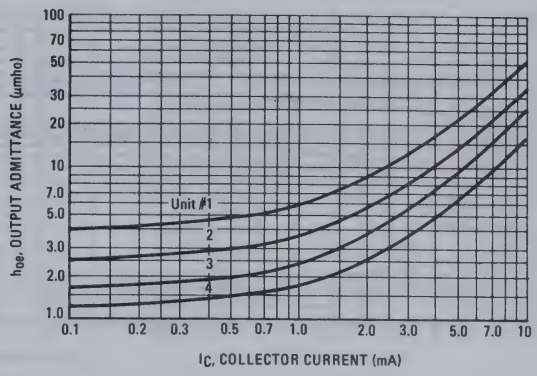


FIGURE 4 – INPUT IMPEDANCE

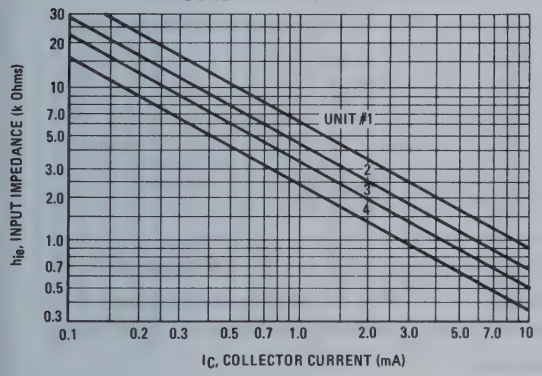


FIGURE 5 – VOLTAGE FEEDBACK RATIO

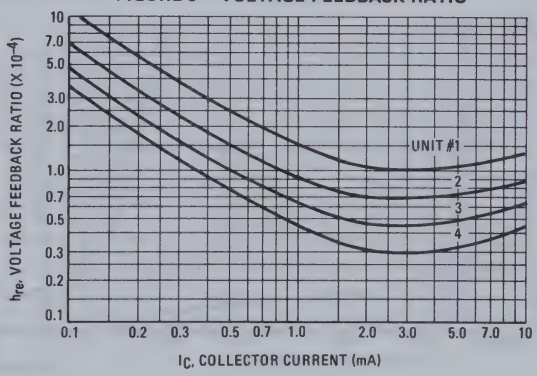
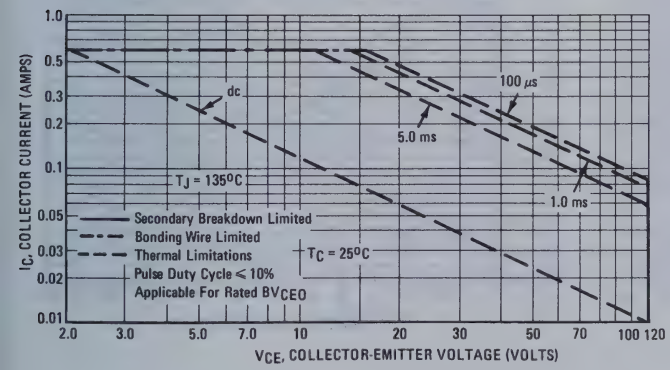


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 135°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

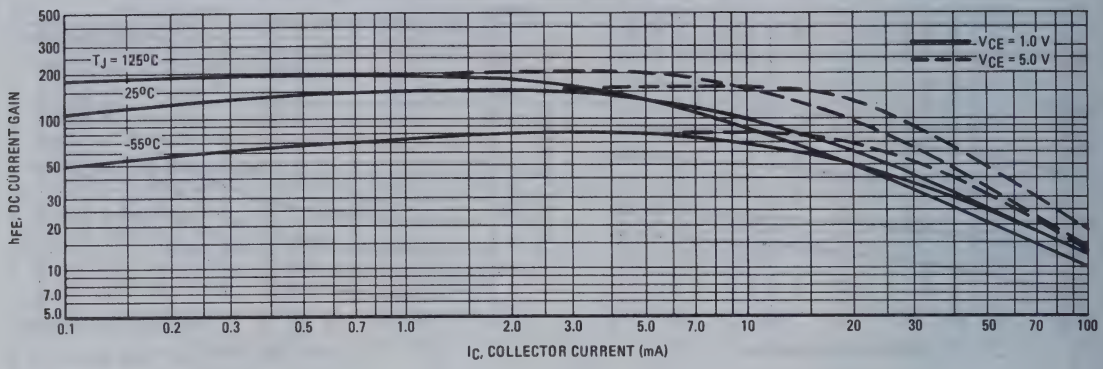


FIGURE 8 – COLLECTOR SATURATION REGION

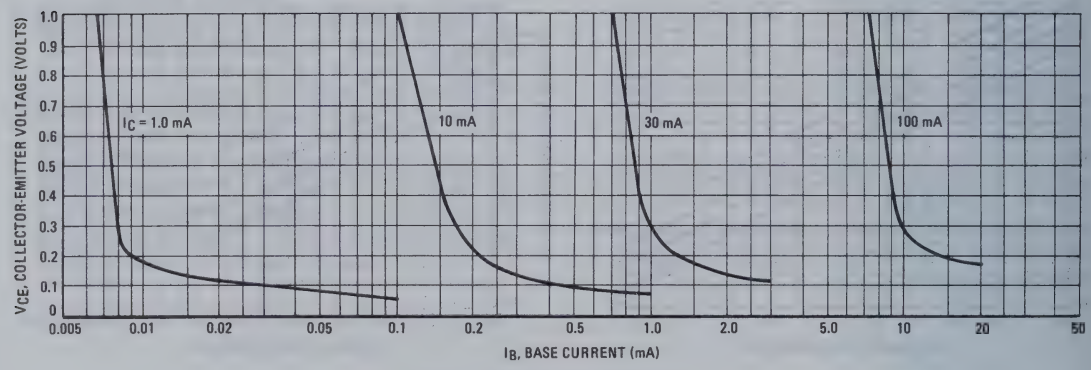


FIGURE 9 – COLLECTOR CUT-OFF REGION

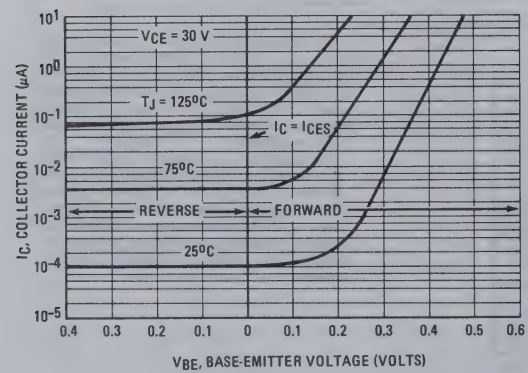


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

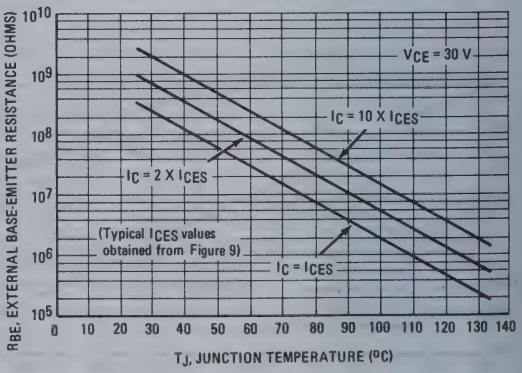


FIGURE 11 – "ON" VOLTAGES

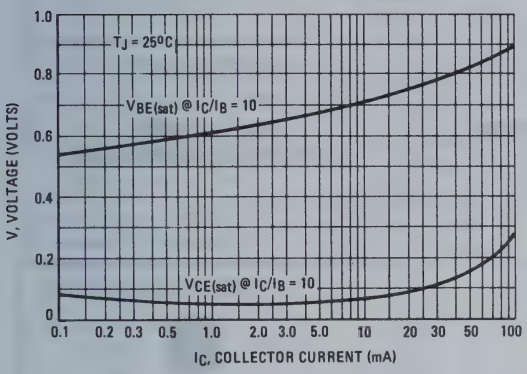


FIGURE 12 – TEMPERATURE COEFFICIENTS

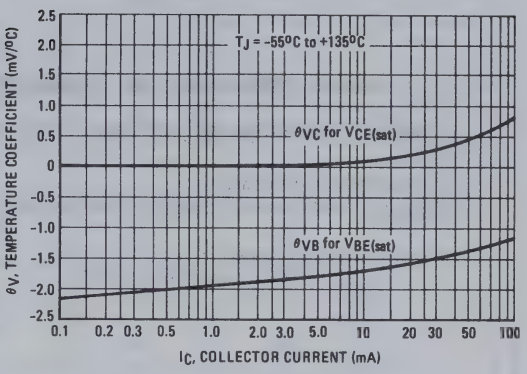


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

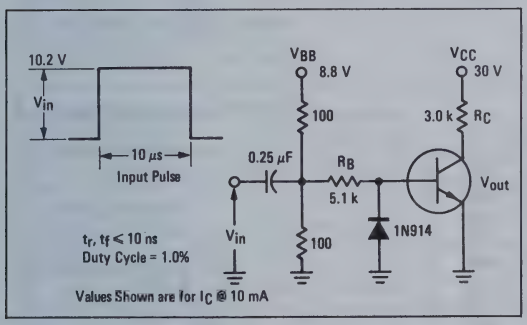


FIGURE 14 – CAPACITANCES

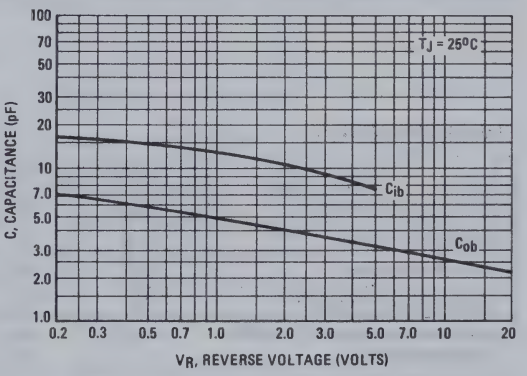


FIGURE 15 – TURN-ON TIME

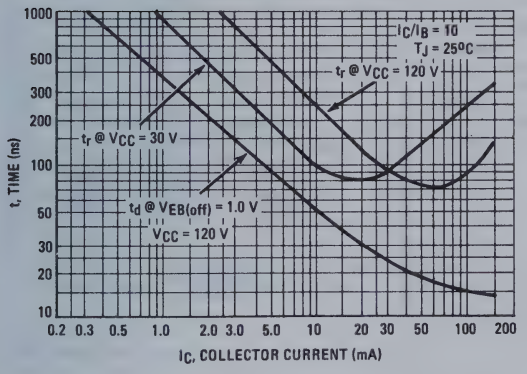
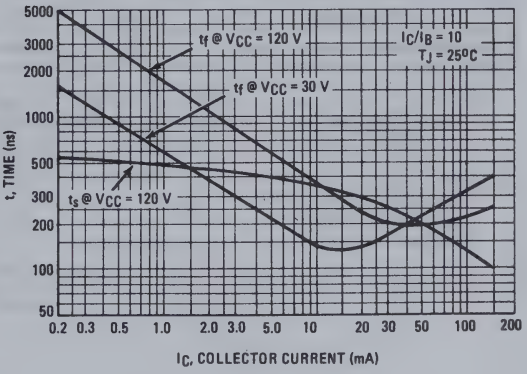


FIGURE 16 – TURN-OFF TIME



MPS-L51 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages —
  BV_{CEO} = 100 Vdc (Min), BV_{CBO} = 100 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (max) @ I_C = 50 mA

HIGH VOLTAGE

PNP SILICON AMPLIFIER TRANSISTOR



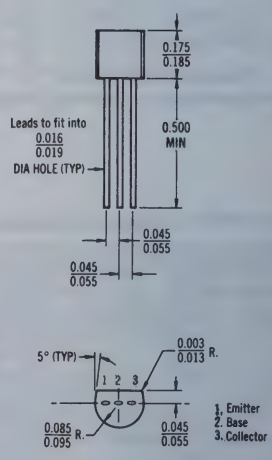
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.357	°C/mW

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 625 mW @ T_A = 25°C, Derate above 25°C — 5.0 mW/°C, P_D = 1.5 W @ T_C = 25°C, Derate above 25°C — 12 mW/°C, θ_{JC} = 83.3°C/W, θ_{JA} = 200°C/W.



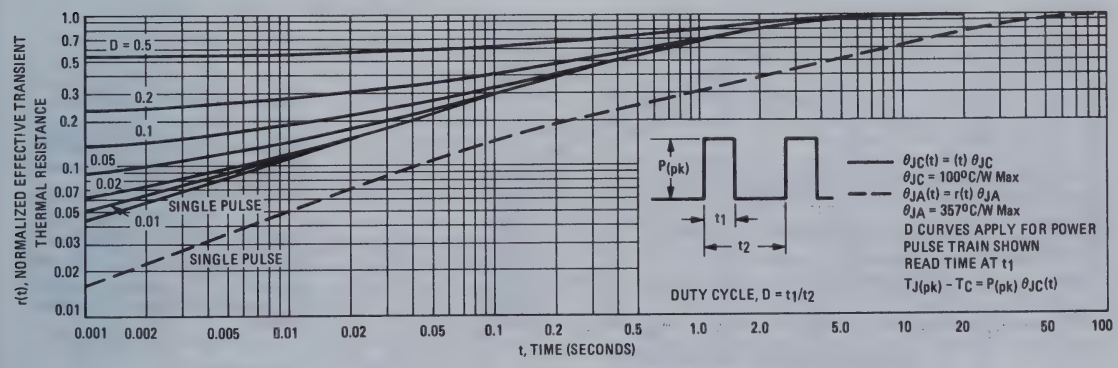
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	40	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.25 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.2 1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	–	–

(1) Pulse Test: Pulse Test = 300 μs. Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

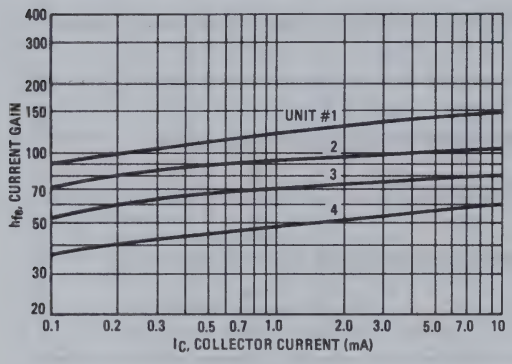


FIGURE 3 – OUTPUT ADMITTANCE

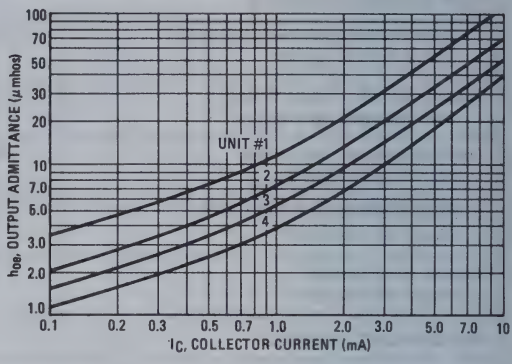


FIGURE 4 – INPUT IMPEDANCE

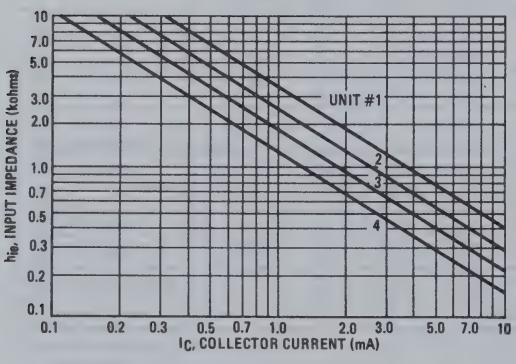


FIGURE 5 – VOLTAGE FEEDBACK RATIO

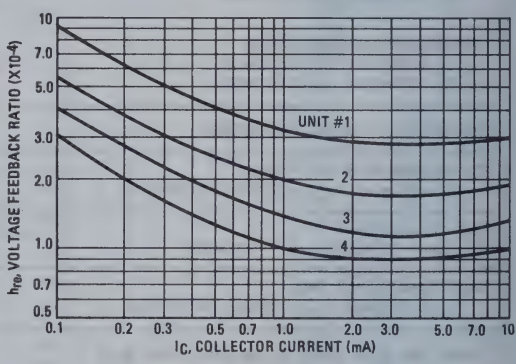
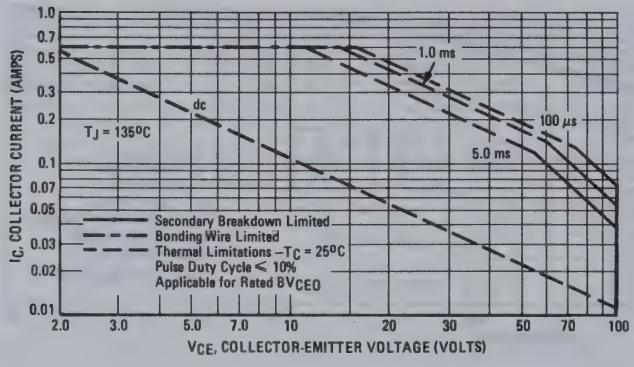


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 135°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

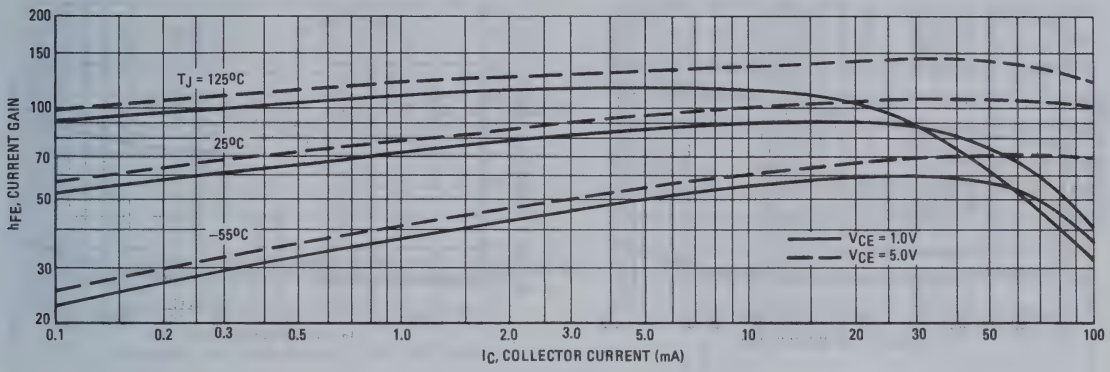


FIGURE 8 – COLLECTOR SATURATION REGION

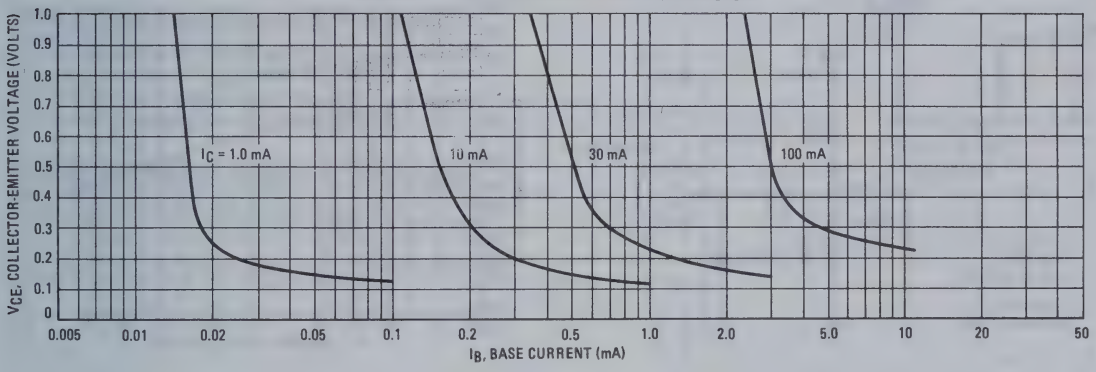


FIGURE 9 – COLLECTOR CUT-OFF REGION

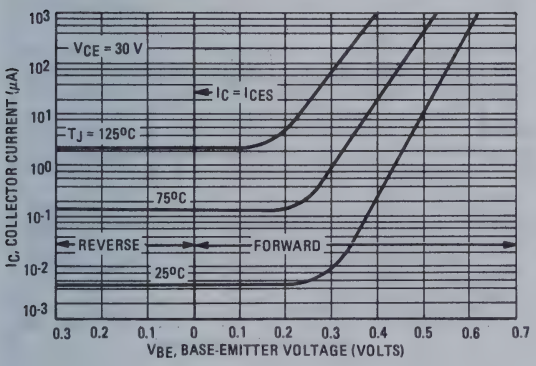


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

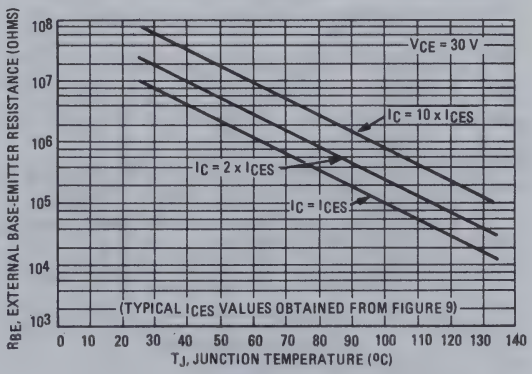


FIGURE 11 – "ON" VOLTAGES

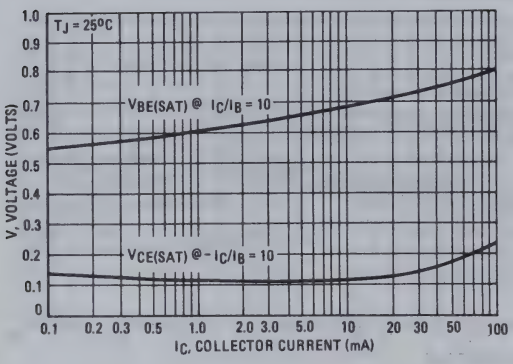


FIGURE 12 – TEMPERATURE COEFFICIENTS

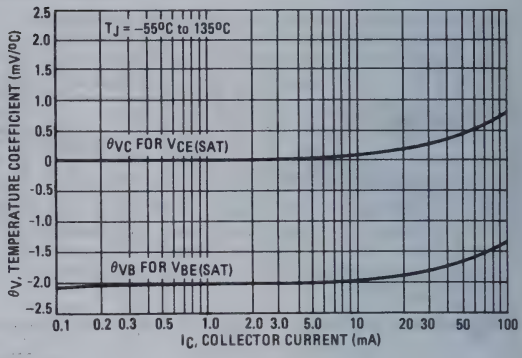


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

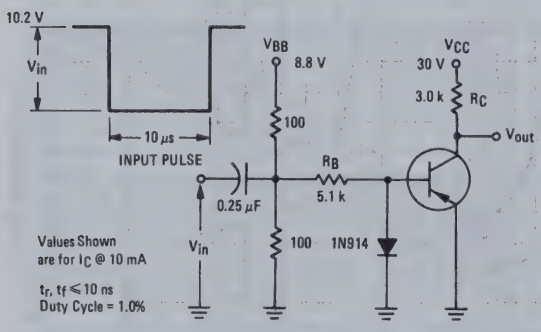


FIGURE 14 – CAPACITANCES

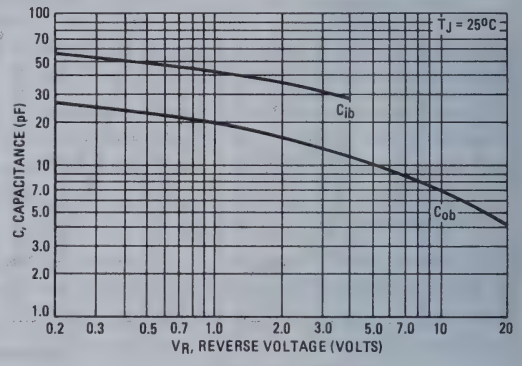


FIGURE 15 – TURN-ON TIME

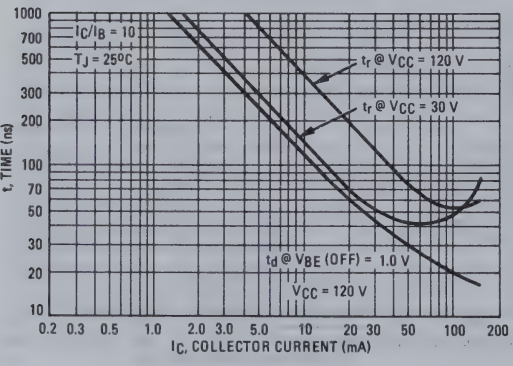
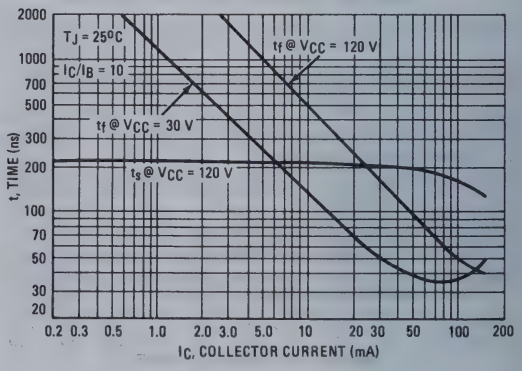


FIGURE 16 – TURN-OFF TIME



MPS-M83 (SILICON)

Advance Information

PNP SILICON ANNULAR TRANSISTORS

. . . designed for common-base UHF RF amplifier applications.

- Guaranteed Noise Figure — NF = 6.5 dB (Max) @ f = 850 MHz
- Guaranteed Forward AGC Characteristics
- Guaranteed Power Gain — G_{pb} = 15 dB (Typ) @ f = 850 MHz
- Low Feedback Capacitance Allowing Stable Unneutralized Operation — C_{ce} = 0.3 pF (Max)

MAXIMUM RATINGS

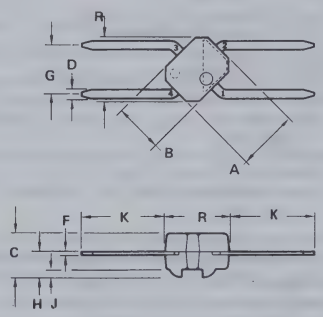
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.357	°C/mW

PNP SILICON UHF TRANSISTORS





STYLE 2:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. BASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.95	5.21	0.195	0.205
B	3.94	4.19	0.155	0.165
C	2.67	2.92	0.105	0.115
D	0.64	0.89	0.025	0.035
F	0.20	0.30	0.008	0.012
G	4.06 BSC		0.160 BSC	
H	1.57	1.83	0.062	0.072
J	0.51	0.76	0.020	0.030
K	6.35	7.62	0.250	0.300
R	5.21	5.46	0.205	0.215

CASE 262-02

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) RAD OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION.

(continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	950	–	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)	C_{ce} (C_{rb})	–	–	0.3	pF
Noise Figure (Figure 7) (I_C = 5.0 mAdc, V_{CC} = 20 Vdc, R_S = 50 Ohms, f = 850 MHz)	NF	–	4.5	6.5	dB
FUNCTIONAL TEST					
Common-Base Amplifier Power Gain (Figure 7) (I_C = 5.0 mAdc, V_{CC} = 20 Vdc, R_S = 50 Ohms) f = 850 MHz)	G_{pb}	10	15	–	dB
Forward AGC Current (Figure 7) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 850 MHz)	I_{AGC}	10	12	14	mAdc
Forward AGC Current at Peak Power Gain (Figures 1, 7) (V_{CB} = 20 Vdc, R_S = 50 Ohms, f = 850 MHz)	–	–	5.0	–	mAdc

AGC CHARACTERISTICS

V_{CB} = 20 Vdc, R_S = 50 Ohms, f = 850 MHz, See Figure 7.

FIGURE 1 – POWER GAIN

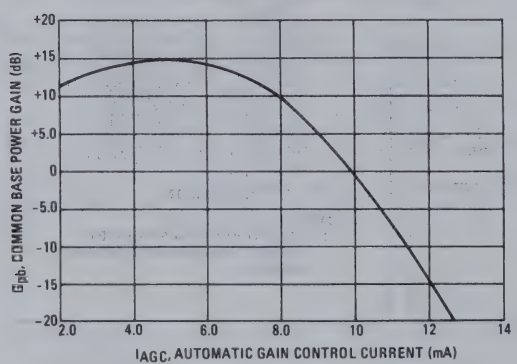
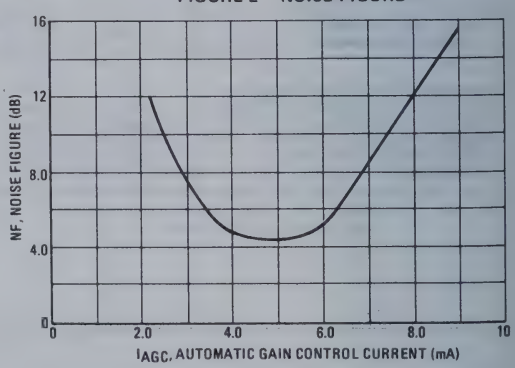


FIGURE 2 – NOISE FIGURE



TYPICAL CHARACTERISTICS

FIGURE 3 – DC CURRENT GAIN

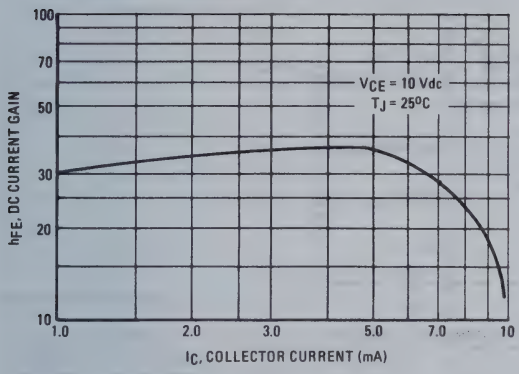


FIGURE 4 – CAPACITANCES

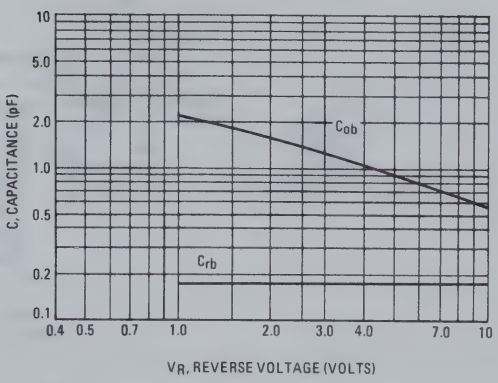


FIGURE 5 – COLLECTOR-BASE TIME CONSTANT

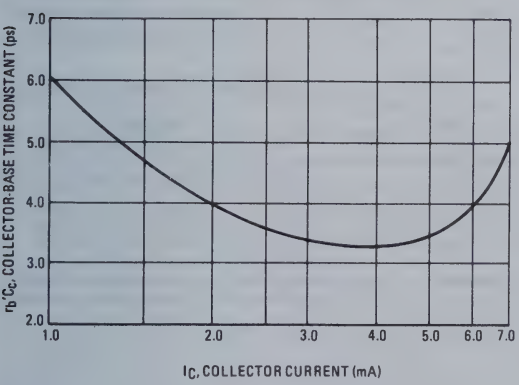


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

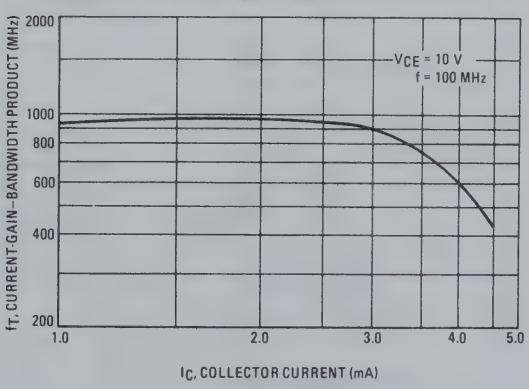
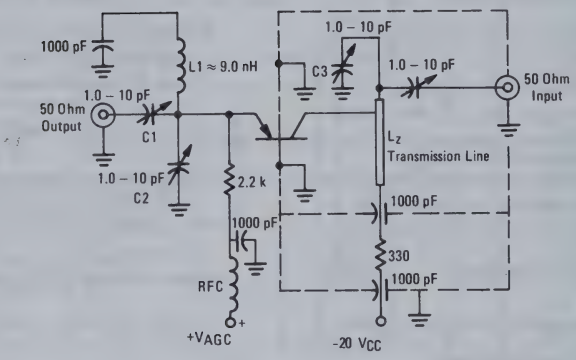


FIGURE 7 – 850 MHz POWER GAIN AND NOISE FIGURE TEST FIXTURE



Adjust C1 and C2 for best VSWR at 850 MHz.
Adjust C3 for best bandpass at 850 MHz.

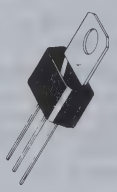
MPS-U01 (SILICON)
MPS-U01A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for complementary symmetry audio circuits to 5 Watts output.

- Excellent Current Gain Linearity — 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 1.0 Adc
- Complements to PNP MPS-U51 and MPS-U51A
- Uniwatt Package for Excellent Thermal Properties — 1.0 Watt @ $T_A = 25^oC$

NPN SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

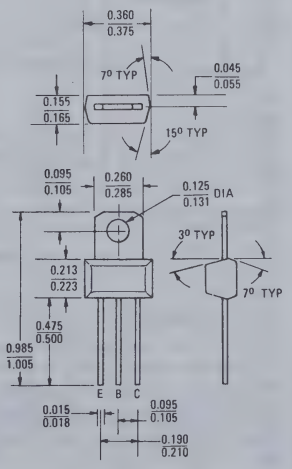
Rating	Symbol	MPS-U01	MPS-U01A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D (1)	1.0 9.10		Watt mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D (1)	8.0 72.8		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	13.7	$^oC/W$
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	110	$^oC/W$

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ $T_A = 25^oC$, Derate above 8.0 mW/^oC, P_D = 10 W @ $T_C = 25^oC$, Derate above 80 mW/^oC, T_J, T_{stg} = -55 to +150^o, $\theta_{JC} = 12.5^oC/W$, $\theta_{JA} = 125^oC$.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.



Collector Connected to Tab

CASE 152

MPS-U01,MPS-U01A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS-U01	BV_{CEO}	30	–	Vdc
	MPS-U01A		40	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-U01	BV_{CBO}	40	–	Vdc
	MPS-U01A		50	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	MPS-U01	I_{CBO}	–	0.1	μAdc
(V_{CB} = 40 Vdc, I_E = 0)	MPS-U01A		–	0.1	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			55	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			50	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	20	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

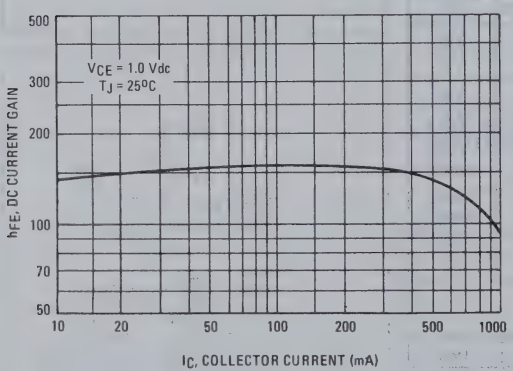


FIGURE 2 – "ON" VOLTAGES

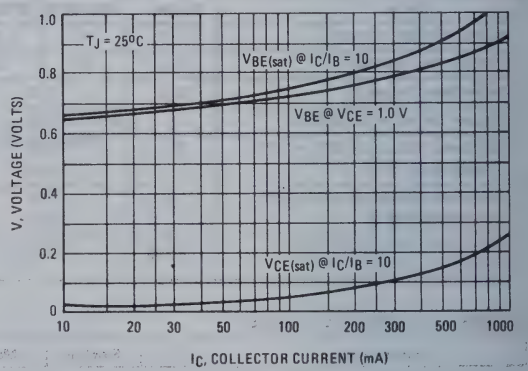
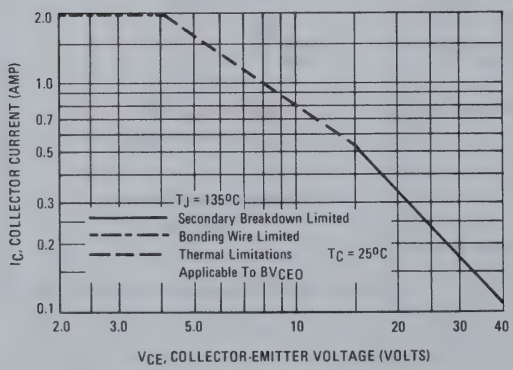


FIGURE 3 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MPS-U02 (SILICON)

NPN silicon annular amplifier transistors designed for general-purpose amplifier and driver applications. Complement to PNP MPS-U52.



Collector connected to tab

CASE 152

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	1.0 9.1	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D (1)	6.0 54.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	18.3	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.110	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 50 50 30	 - 300 -	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	10	pF

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_A = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J,T_{stg} = -55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

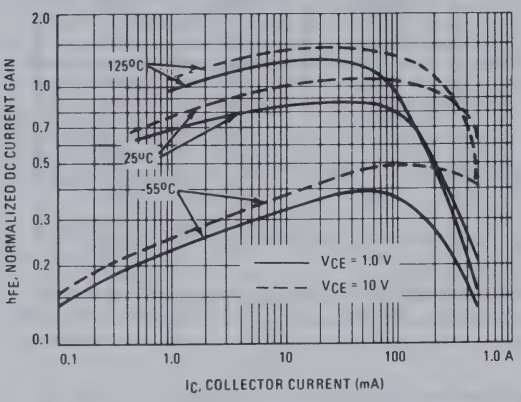


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

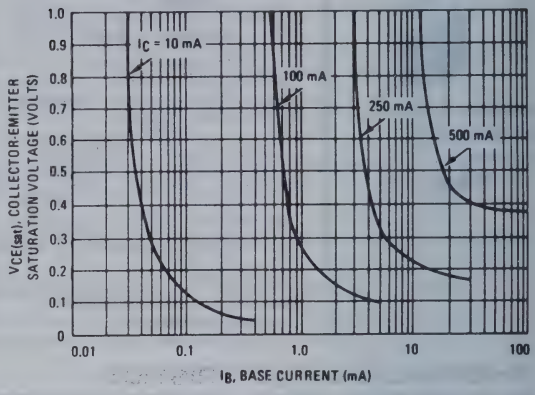


FIGURE 3 – BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

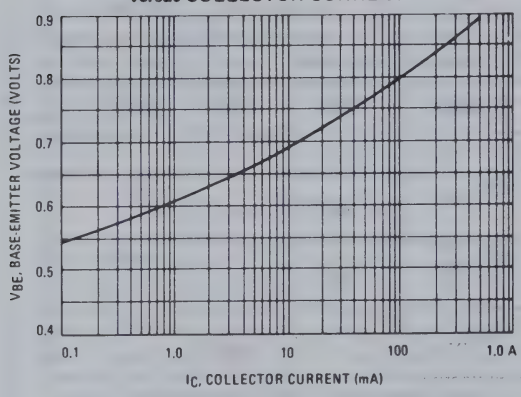


FIGURE 4 – CAPACITANCE versus VOLTAGE

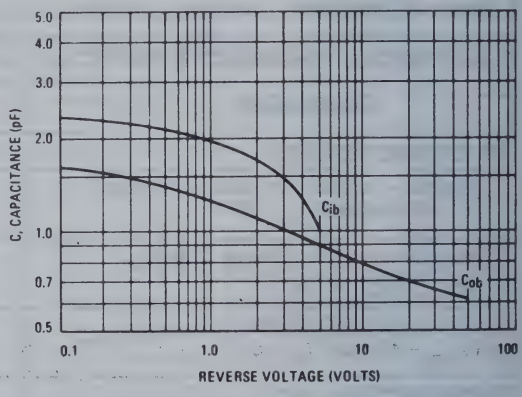


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

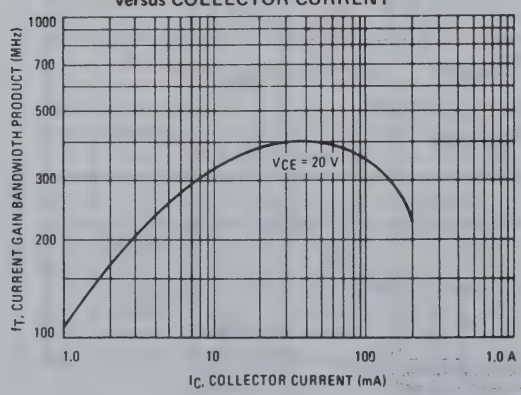
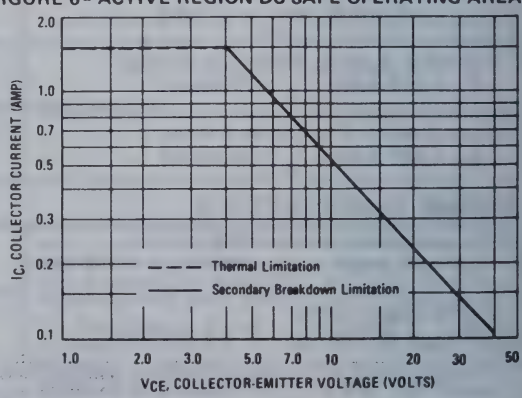
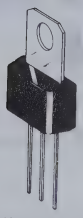


FIGURE 6 – ACTIVE REGION DC SAFE OPERATING AREA



MPS-U03 (SILICON)
MPS-U04

NPN silicon annular plastic transistors designed for video output circuits utilizing an emitter-follower driver and for horizontal driver applications in television receivers.



CASE 152

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	MPS-U03	MPS-U04	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Collector-Base Voltage	V_{CB}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	1.0 9.09		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D (1)	8.0 72.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPSU03 MPSU04	BV_{CEO}	120 180	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSU03 MPSU04	BV_{CBO}	120 180	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0)	MPSU03 MPSU04	I_{CBO}	- -	0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	40	-	-
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	110	pF

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_A = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J,T_{stg} = -55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

MPS-U05 (SILICON)
MPS-U06

NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U05
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U06
- High Power Dissipation – P_D = 10 W @ T_C = 25°C
- Complements to PNP MPS-U55 and MPS-U56

NPN SILICON AMPLIFIER TRANSISTORS

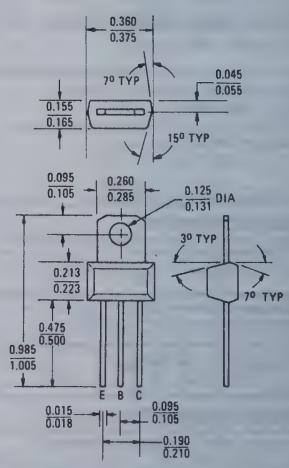


MAXIMUM RATINGS

Rating	Symbol	MPS-U05	MPS-U06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W



Collector Connected to Tab
CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U05 MPS-U06	BV_{CEO}	 60 80	 – –	 – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MPS-U05 MPS-U06	I_{CBO}	 – –	 – –	 100 100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 80 60 –	 125 100 55	 – – –	–
Collector-Emitter Saturation Voltage(1) (I_C = 250 mAdc, I_B = 10 mAdc) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	 – –	 0.18 0.1	 0.4 –	Vdc
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.74	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	150	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.0	12	pF

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DC CURRENT GAIN

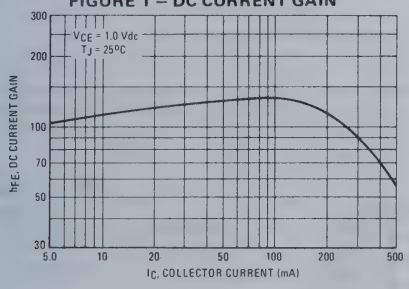


FIGURE 2 – "ON" VOLTAGES

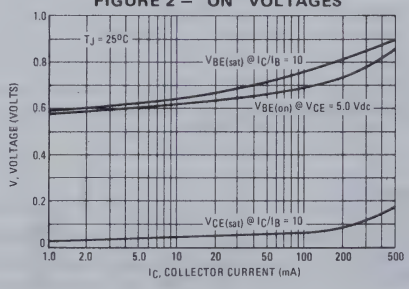


FIGURE 3 – DC SAFE OPERATING AREA

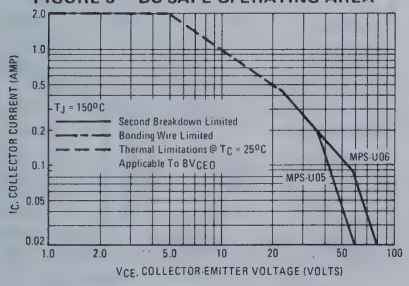
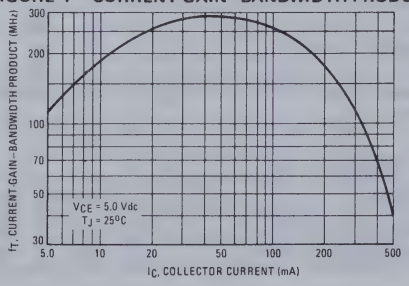


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown

MPS-U07 (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- High Power Dissipation — P_D = 10 W @ T_C = 25°C
- Complement to PNP MPS-U57

NPN SILICON AMPLIFIER TRANSISTORS

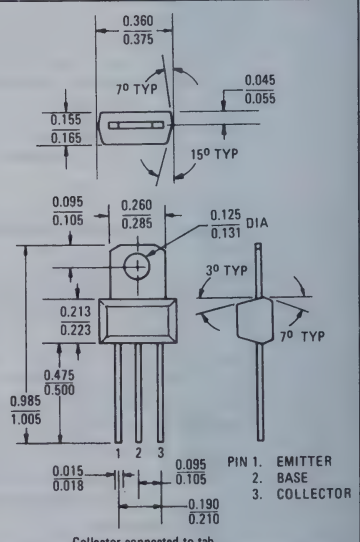


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W



Collector connected to tab

To convert inches to millimeters multiply by 25.4

CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 30 –	 110 65 30	 – – –	–
Collector-Emitter Saturation Voltage (1) (I_C = 250 mAdc, I_B = 10 mAdc) (I_C = 250 mAdc, I_B = 25 mAdc)	$V_{CE(sat)}$	 – –	 0.18 0.1	 0.4 –	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.74	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	50	150	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	6.0	12	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

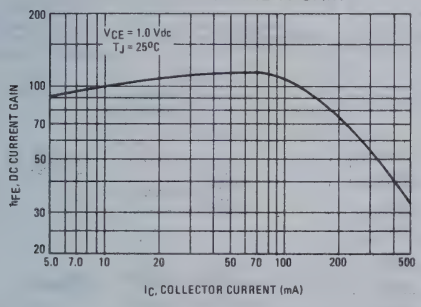


FIGURE 2 – "ON" VOLTAGES

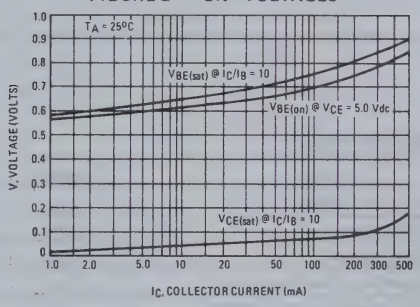


FIGURE 3 – DC SAFE OPERATING AREA

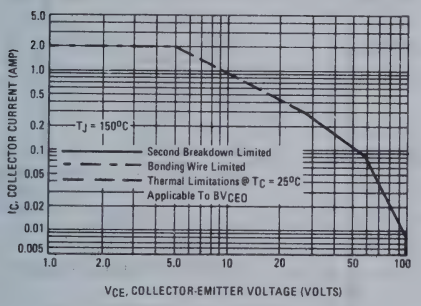
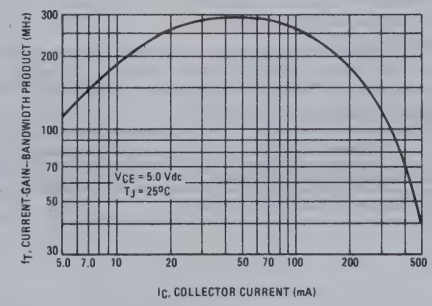


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown

MPS-U10 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-voltage video and luminance output stages in TV receivers.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 300 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 30 mAdc
- Low Collector-Base Capacitance —
  C_{cb} = 3.0 pF (Max) @ V_{CB} = 20 Vdc

NPN SILICON HIGH VOLTAGE AMPLIFIER TRANSISTOR

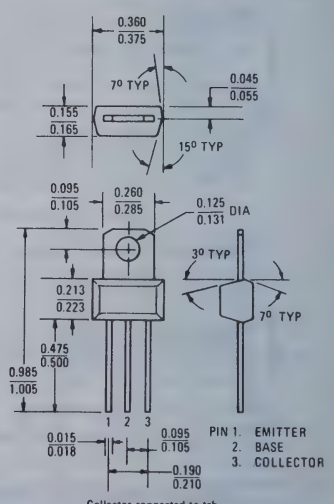


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W



Collector connected to tab

To convert inches to millimeters multiply by 25.4

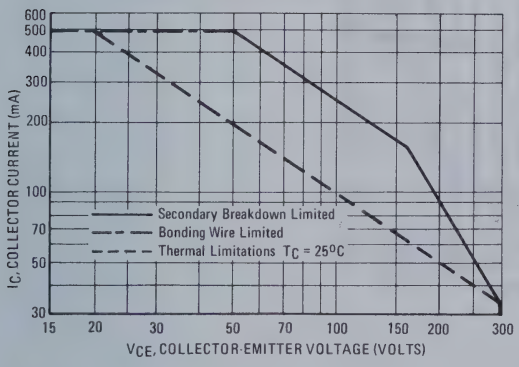
CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	8.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	–	0.2	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		40	–	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		40	–	
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	–	0.75	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	60	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	3.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 1 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – DC CURRENT GAIN

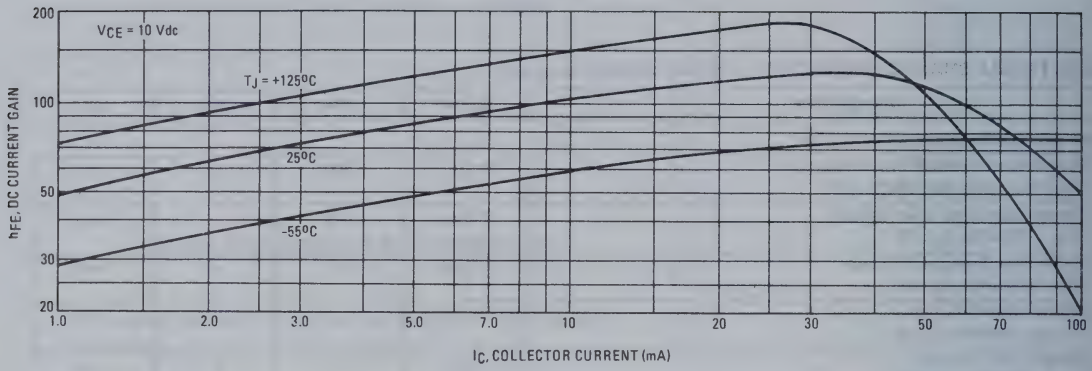


FIGURE 3 – CAPACITANCES

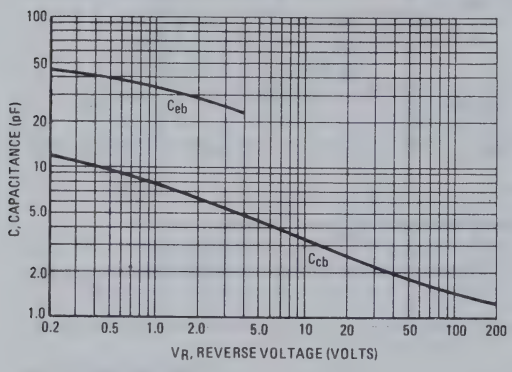


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

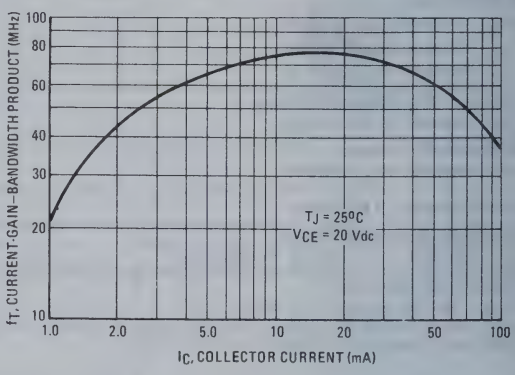
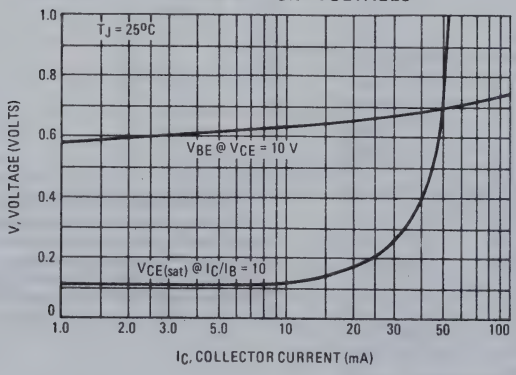


FIGURE 5 – "ON" VOLTAGES



APPLICATIONS INFORMATION

The MPS-U10 is primarily designed for use in the R, G, and B output stages of color television receivers and with a high BV_{CEO}, it can supply the video amplitude requirements of any known system. The low feedback capacitance provides good video bandwidth with modest drive current requirements. Typical drive is from an emitter-follower with a 4.7 k emitter-resistor operated from a 20-Volt supply. It will, therefore, be operable directly from a number of available chroma demodulators. The low output capacitance of this device adds little to the total load capacitance, allowing improved bandwidth for a given collector load resistor. Two typical applications for the MPS-U10 are shown in Figures 6 and 7.

Device dissipation will reach approximately 1.6 Watts under worst-case signal conditions and some heat sinking is required. At an operating ambient temperature of 65°C, a thermal resistance θ_{JA} = 150-65/1.6 = 53°C/W will be required. The junction-to-case thermal resistance, θ_{JC}, of the device is 12.5°C/W, thus a heat dissipator of 40.5°C/W, or lower, will be required. A black anodized 0.020" thick aluminum plate measuring 1" x 2" can be folded into a channel shape and formed with "feet" to snap into a printed circuit panel for support. This will provide the safety factor.

Used as a color difference output, where drive and bandwidth requirements are less severe, the MPS-U10 can be operated with 27 k ohm load resistors (worst-case dissipation would then be only 0.6 Watts). The device can, therefore, be operated as a color-difference output without any heat radiator in ambient temperatures to 150-0.6 (125) = 75°C.

In addition the safe operating area of the MPS-U10 will fill the requirements of the luminance output function with a total equivalent load of 5.0 kilohms. Worst-case dissipation can reach 3 Watts, this requires a total θ_{JA} of 150-65/3 = 28.4°C/W. This 28.4°C/W means a heat dissipator of 15.9°C/W, (approximately 2" x 3" aluminum plate) will be required.

FIGURE 6 – MPS-U10 AS RGB OUTPUT WITH RGB INPUT

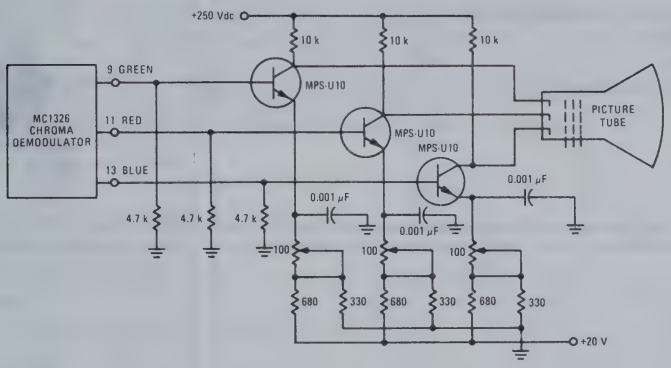
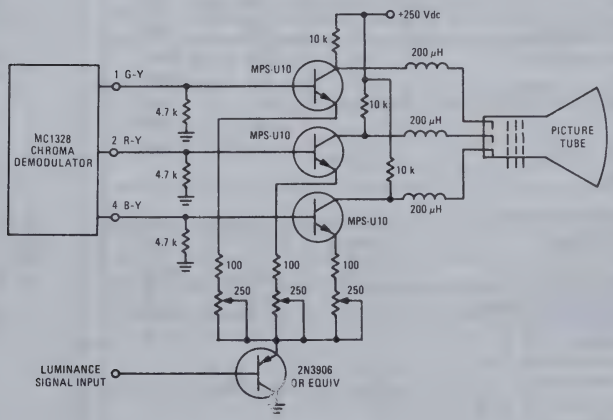


FIGURE 7 – MPS-U10 AS RGB OUTPUT, MATRIXING COLOR DIFFERENCE AND LUMINANCE INPUTS



MPS-U31 (SILICON)

NPN SILICON ANNULAR RF TRANSISTOR

. . . designed for use in Citizen-Band and other high-frequency communications equipment operating to 30 MHz. Higher breakdown voltages allow a high percentage of up-modulation in AM circuits. This device is designed to be used with the MPS8000 driver and the MPS8001 RF oscillator.

- Output Power = 3.5 W (Min) @ V_{CC} = 13.6 Vdc
- Power Gain = 11.5 dB (Min)
- High Collector-Emitter Breakdown Voltage — $BV_{CES} \geq 65$ Vdc
- DC Current Gain — Linear to 500 mAdc (Typ)

3.5 W — 27 MHz

RF POWER OUTPUT TRANSISTOR

NPN SILICON

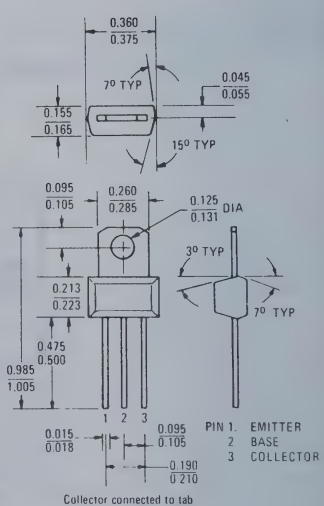


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	65	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JA}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W



CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 150 mAdc, V_{BE} = 0)	BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (2) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	40	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 3.5 W, V_{CC} = 13.6 Vdc, f = 27 MHz)	G_{PE}	11.5	–	–	dB
Output Power (P_{in} = 350 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	P_{out}	3.5	–	–	Watts
Collector Efficiency (3) (P_{out} = 3.5 W, V_{CC} = 13.6 Vdc, f = 27 MHz)	η	–	85	–	%
Percentage Up-Modulation (4) (f = 27 MHz)	–	–	85	–	%

(1) Pulsed thru a 25 mH Indicator.

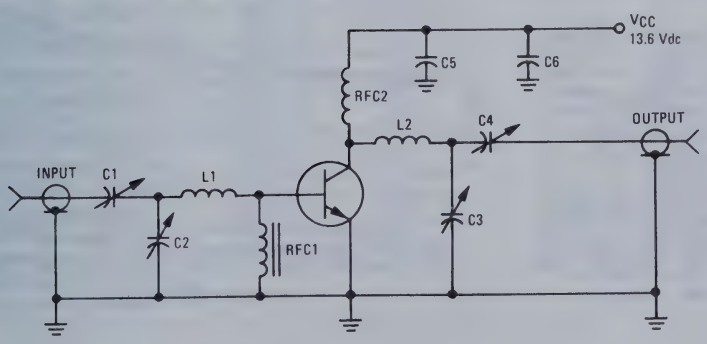
(2) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

(3) $\eta = \dfrac{R_F P_{out}}{(V_{CC})(I_C)} \bullet 100$

(4) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 13.6 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \bullet 100$$

FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2 9.0-180 pF ARCO 463 or Equivalent
C3, C4 5.0-80 pF ARCO 462 or Equivalent
C5 0.02 μF Ceramic Disc
C6 0.1 μF Ceramic Disc
RFC1 4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2 26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) ¼" Inner Diameter
L1 0.22 μH Molded Choke
L2 0.68 μH Molded Choke

POWER OUTPUT

FIGURE 2 – V_{CC} = 12.5 Vdc

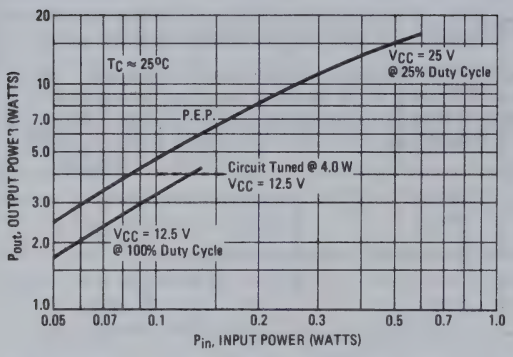


FIGURE 3 – V_{CC} = 13.6 Vdc

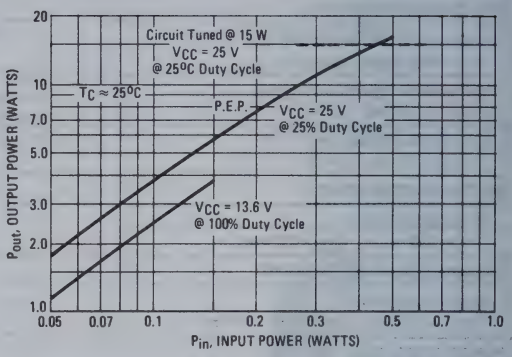


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

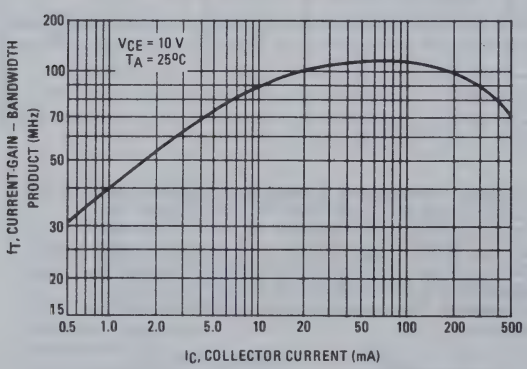


FIGURE 5 – CAPACITANCE

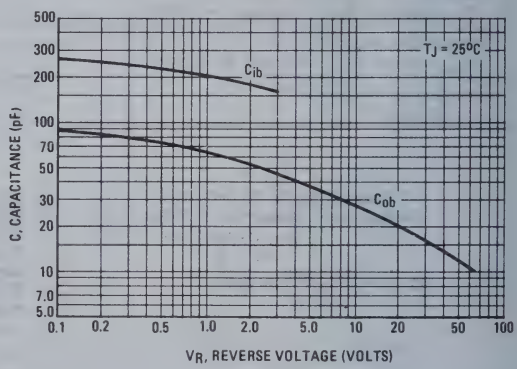


FIGURE 6 – DC CURRENT GAIN

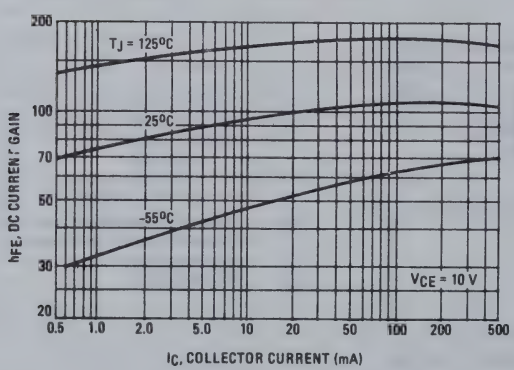


FIGURE 7 – ON VOLTAGES

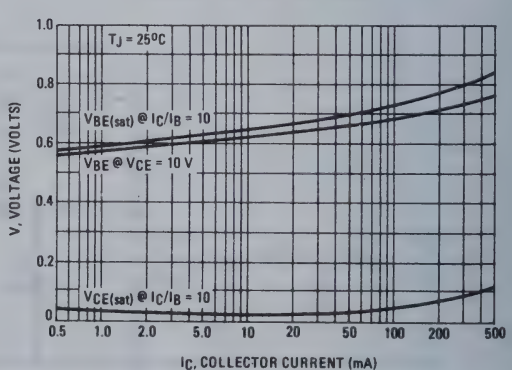
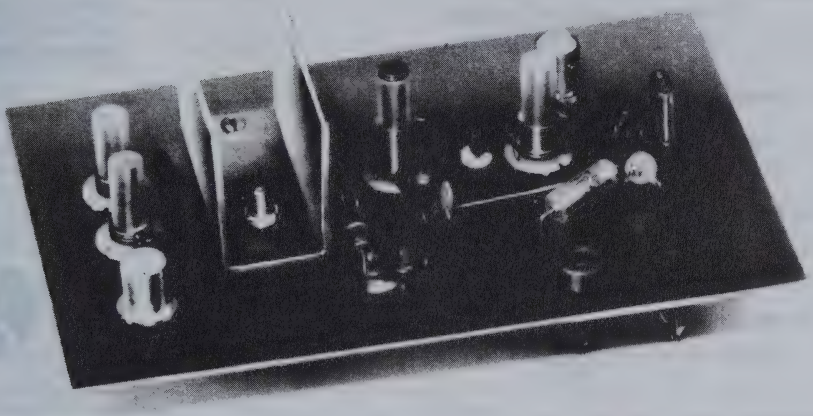
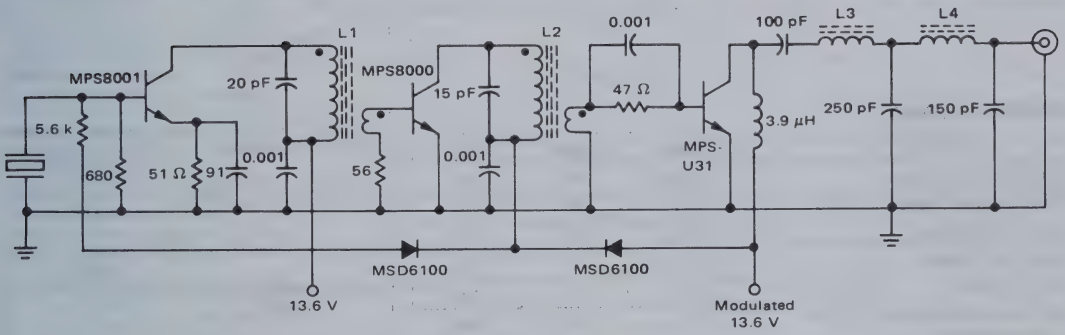


FIGURE 8 – TYPICAL APPLICATION – 27 MHz CITIZEN-BAND TRANSMITTER



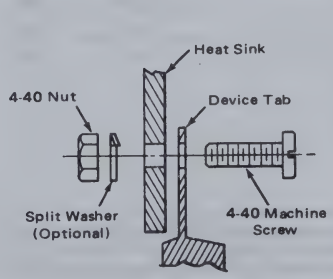


For complete information on this circuit, refer to Motorola Application Note, AN-596.

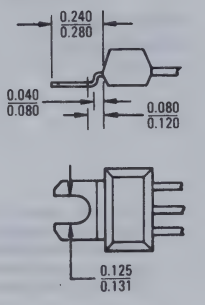
Case-(Tab)-to-Sink Thermal Resistances ($R_{\theta CS}$) for Common Mounting Methods

Condition	$R_{\theta CS}$ In °C/W	Mounting Screw Torque (in./lbs.)
No Grease	4.25	5
With Dow-340 Thermal Compound	2.1 1.7	2 5
With Dow-340 and 2 mil Mica Washer	4.7 4.3	2 5
With 0.1" Chassis Block and Dow-340	2.4	5
With 0.1" Block, Dow-340 and 2 mil Mica Washer	4.9	5
With 0.062" Block and Dow-340	2.2	5
With 0.062" Block, Dow-340 and 2 mil Mica Washer	4.7	5

LEAD FORM AND MOUNTING INFORMATION FOR UNIWATT PACKAGE



For additional information see Application Note AN-472.



Tab formed for flush mounting order as MPS-U31-1

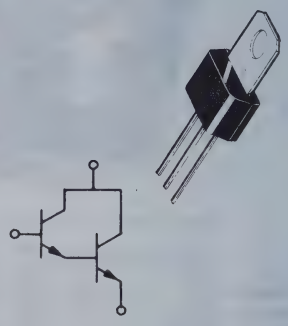
MPS-U45 (SILICON)

NPN SILICON DARLINGTON AMPLIFIER TRANSISTOR

. . . designed for amplifier and driver applications.

- High DC Current Gain –
  h_{FE} = 25,000 (Min) @ I_C = 200 mAdc
  15,000 (Min) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage –
  BV_{CES} = 40 Vdc (Min) @ I_C = 100 μAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc @ I_C = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to PNP MPS-U95

NPN SILICON DARLINGTON TRANSISTOR

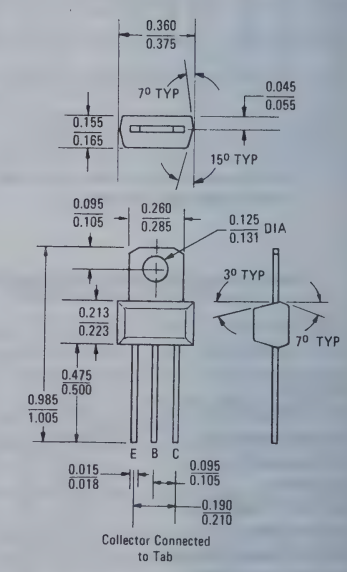


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}(1)	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	12	Vdc
Collector Current	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W



CASE 152

(1) Due to the monolithic construction of this device, breakdown voltages of both transistor elements are identical. BV_{CES} is tested in lieu of BV_{CEO} in order to avoid errors caused by noise pickup. The voltage measured during the BV_{CES} test is the BV_{CEO} of the output transistor.

MPS-U45 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	12	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)		25,000	65,000	150,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		15,000	35,000	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		4,000	12,000	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	1.2	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	1.85	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	1.7	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\|h_{fe}\|$	1.0	3.2	–	–
Collector Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	2.5	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Uniwatt darlington transistors can be used in any number of low power applications, such as relay drivers, motor control and as general purpose amplifiers. As an audio amplifier these devices, when used as a complementary pair, can drive 3.5 watts into a 3.2 ohm speaker using a 14 volt supply with less than one per cent distortion. Because of the high gain the base drive requirement is as low as 1 mA in this application. They are also useful as power drivers for high current application such as voltage regulators.

FIGURE 1 – DC CURRENT GAIN

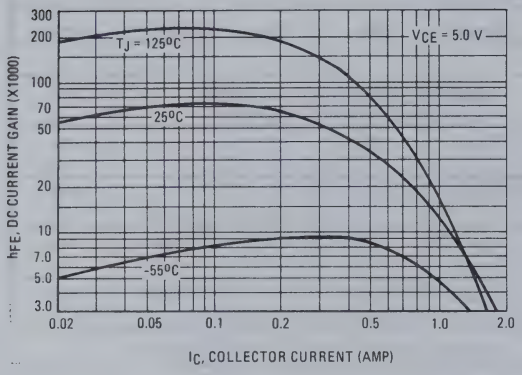


FIGURE 2 – SMALL-SIGNAL CURRENT GAIN

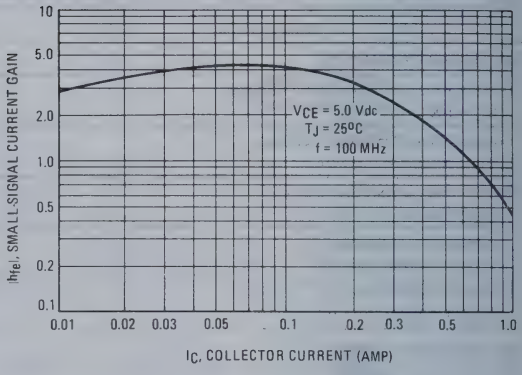


FIGURE 3 – "ON" VOLTAGES

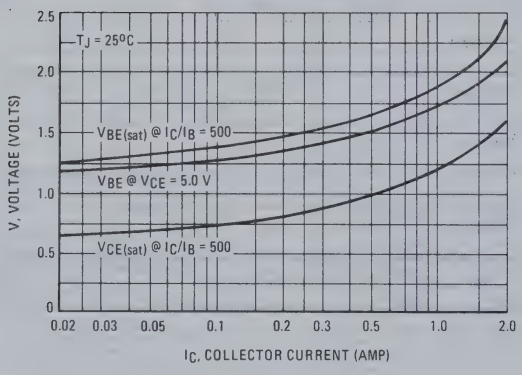


FIGURE 4 – TEMPERATURE COEFFICIENT

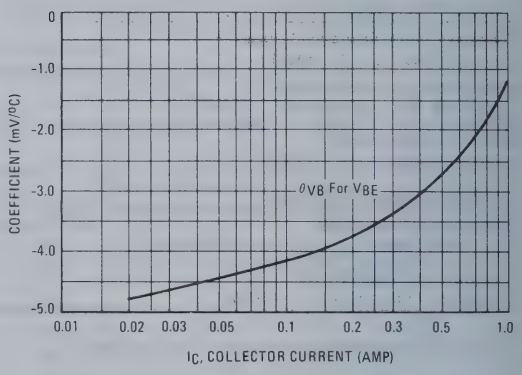
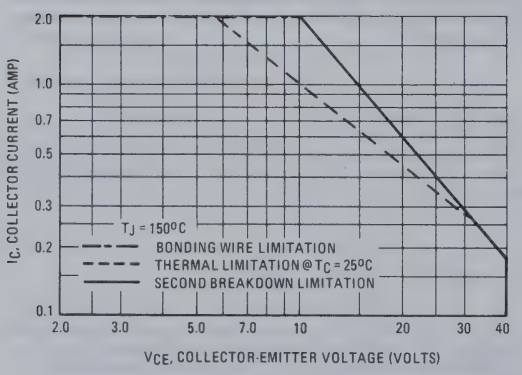


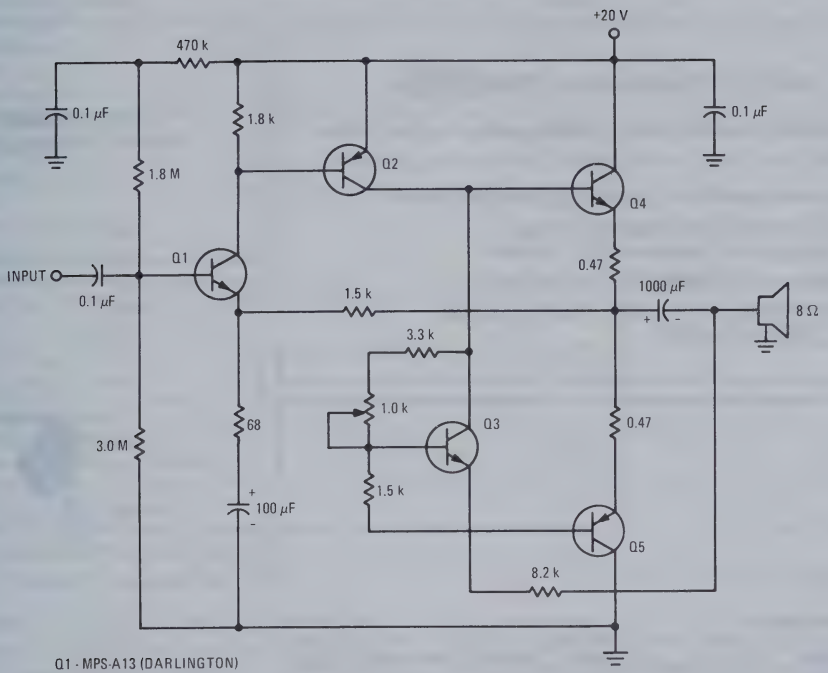
FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

5-WATT AUDIO AMPLIFIER



Q1 - MPS-A13 (DARLINGTON)
Q2 - MPS-A70
Q3 - MPS-A20
Q4 - MPS-U45 } COMPLEMENTARY
Q5 - MPS-U95 } DARLINGTONS

MPS-U51 (SILICON)
MPS-U51A

PNP SILICON ANNULAR TRANSISTORS

. . . designed for complementary symmetry audio circuits to 5 Watts output.

- Excellent Current Gain Linearity — 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- Complements to NPN MPS-U01 and MPS-U01A
- Uniwatt Package for Excellent Thermal Properties — 1.0 Watt @ $T_A = 25^oC$

PNP SILICON AUDIO TRANSISTORS

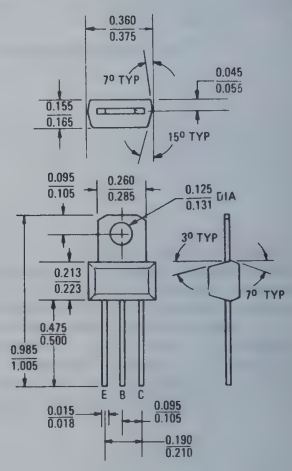


MAXIMUM RATINGS

Rating	Symbol	MPS-U51	MPS-U51A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D (1)	1.0 9.10		Watt mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D (1)	8.0 72.8		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	13.7	$^oC/W$
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	110	$^oC/W$



Collector Connected to Tab
CASE 152

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ $T_A = 25^oC$, Derate above 8.0 mW/^oC, P_D = 10 W @ $T_C = 25^oC$, Derate above 80 mW/^oC, T_J, T_{stg} = -55 to +150°, θ_{JC} = 12.5$^oC/W$, θ_{JA} = 125^oC.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

MPS-U51,MPS-U51A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U51	BV_{CEO}	30	–	Vdc
	MPS-U51A		40	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-U51	BV_{CBO}	40	–	Vdc
	MPS-U51A		50	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)	MPS-U51		–	0.1	
(V_{CB} = 40 Vdc, I_E = 0)	MPS-U51A		–	0.1	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			55	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			50	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	30	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

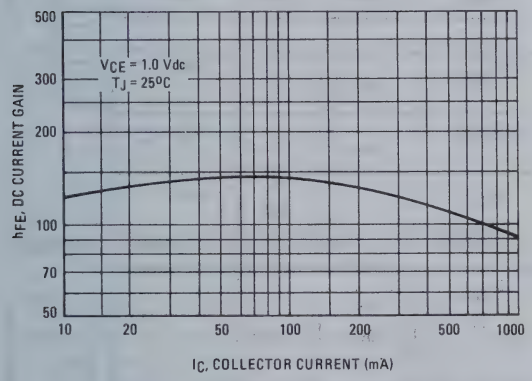


FIGURE 2 – "ON" VOLTAGES

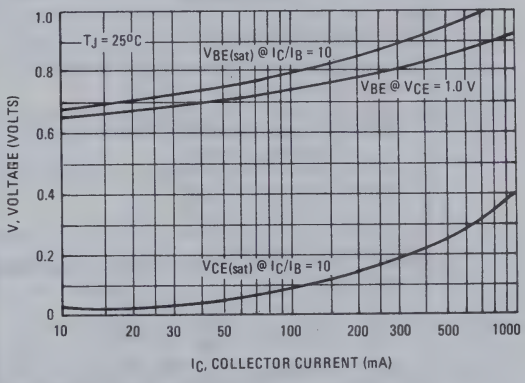
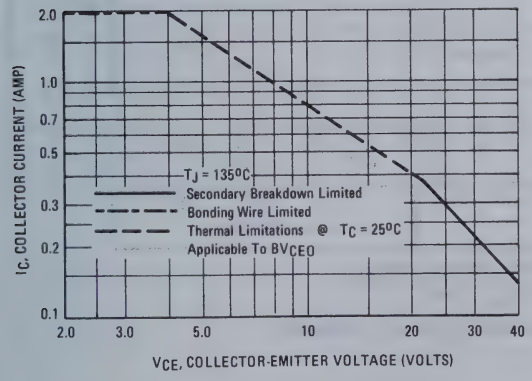


FIGURE 3 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MPS-U52 (SILICON)

PNP silicon annular amplifier transistors designed for general-purpose amplifier and driver applications. Complement to NPN MPS-U02.



CASE 152

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	1.0 9.1	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D (1)	6.0 54.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC} (1)	18.3	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	0.110	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 50 50 30	 - 300 -	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	24	pF

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_A = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J,T_{stg} = -55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

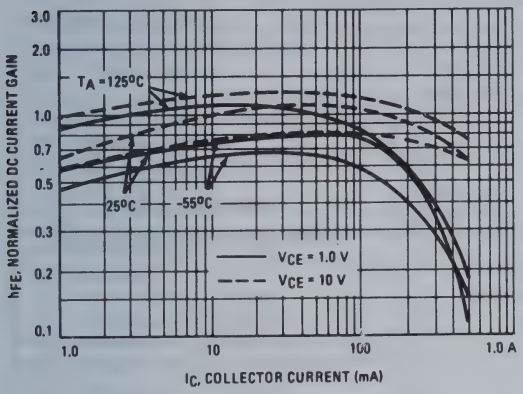


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

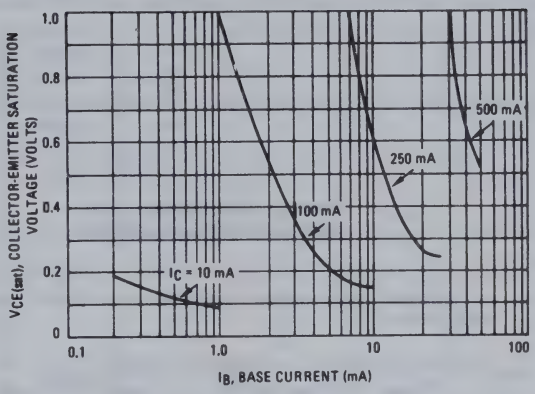


FIGURE 3 – TRANSCONDUCTANCE

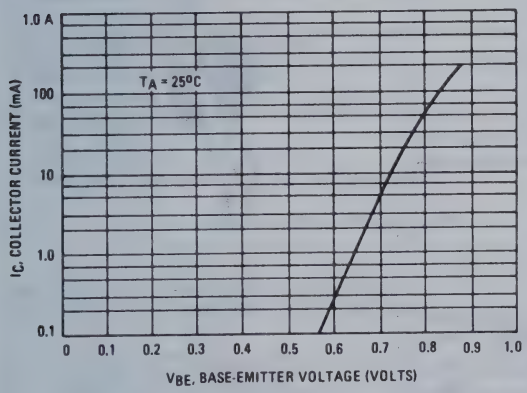


FIGURE 4 – CAPACITANCE versus VOLTAGE

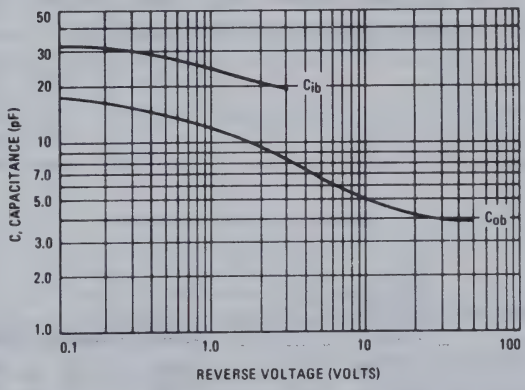


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

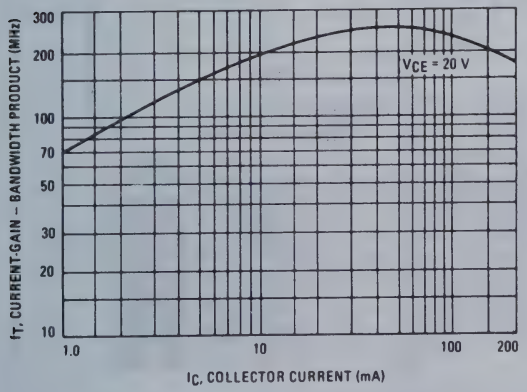
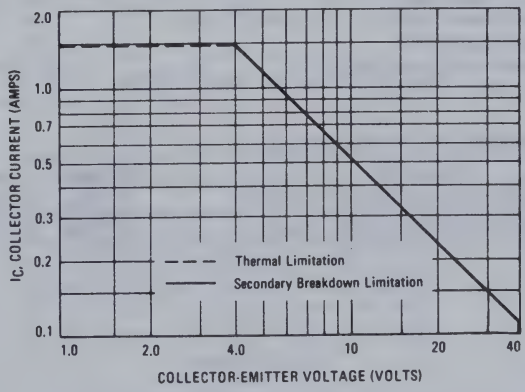


FIGURE 6 – ACTIVE DC SAFE OPERATING AREA



MPS-U55 (SILICON)
MPS-U56

PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U55
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U56
- High Power Dissipation – P_D = 10 W @ T_C = 25°C
- Complements to NPN MPS-U05 and MPS-U06

PNP SILICON AMPLIFIER TRANSISTORS

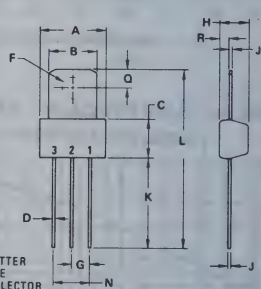


MAXIMUM RATINGS

Rating	Symbol	MPS-U55	MPS-U56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	2.0		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

Collector Connected to Tab
CASE 152-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U55	BV_{CEO}	60	–	–	Vdc
	MPS-U56		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 40 Vdc, I_E = 0)	MPS-U55		–	–	100	
(V_{CB} = 60 Vdc, I_E = 0)	MPS-U56		–	–	100	
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			80	160	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			50	130	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			–	80	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 10 mAdc)			–	0.22	0.5	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.15	–	
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	10	15	pF

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DC CURRENT GAIN

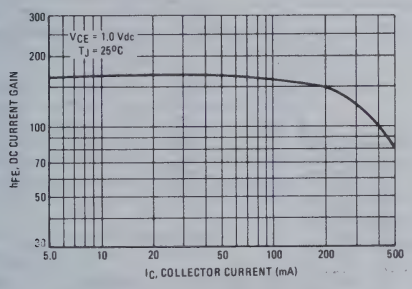


FIGURE 2 – "ON" VOLTAGES

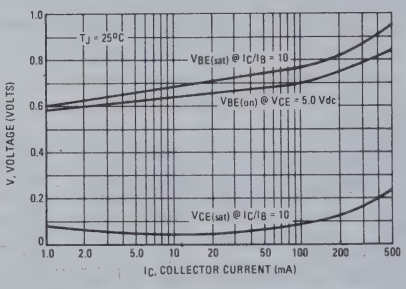


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA

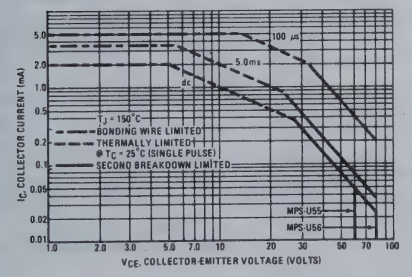
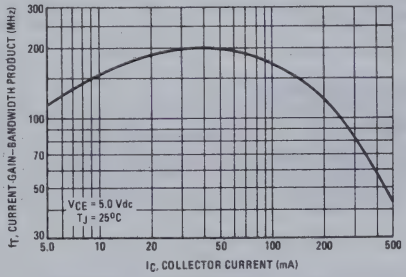


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415A)

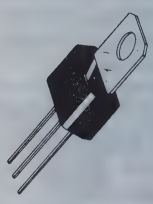
MPS-U57 (SILICON)

PNP SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- High Power Dissipation — P_D = 10 W @ T_C = 25°C
- Complement to NPN MPS-U07

AMPLIFIER TRANSISTOR PNP SILICON

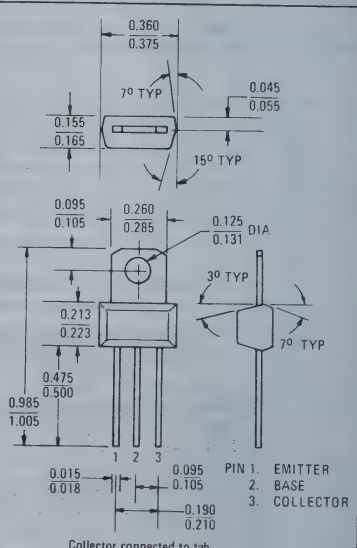


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W



Collector connected to tab

To convert inches to millimeters multiply by 25.4

CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 60 30 –	 140 65 30	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 10 mAdc) (I_C = 250 mAdc, I_B = 25 mAdc)	$V_{CE(sat)}$	 – –	 0.24 0.15	 0.5 –	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	50	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	15	pF

FIGURE 1 – DC CURRENT GAIN

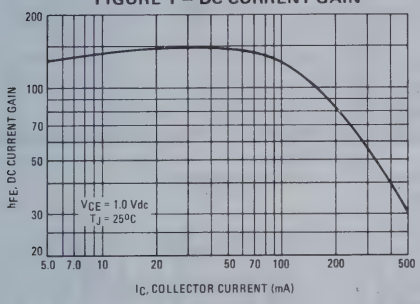


FIGURE 2 – "ON" VOLTAGES

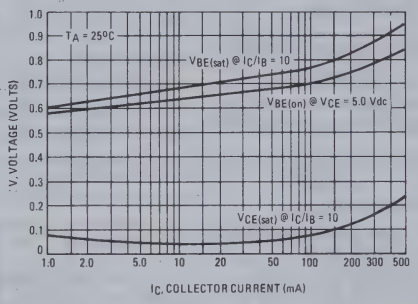


FIGURE 3 – DC SAFE OPERATING AREA

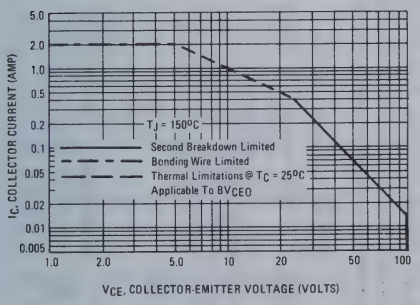
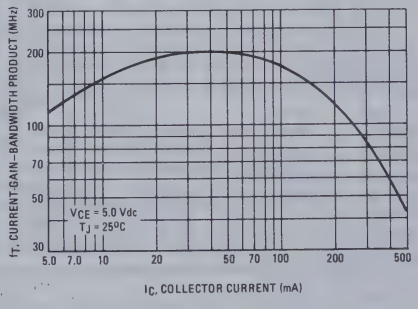


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

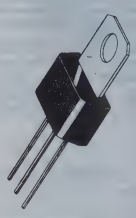
MPS-U60 (SILICON)

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- Complement to NPN Type MPS-U10

PNP SILICON HIGH VOLTAGE TRANSISTORS



MAXIMUM RATINGS

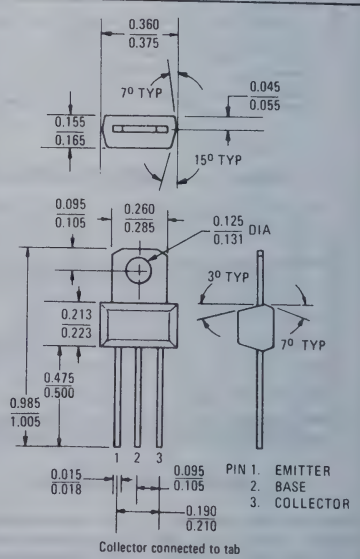
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	12.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	125	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	–	0.2	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25 30 30	– – –	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	60	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	8.0	pF



CASE 152

FIGURE 1 – DC CURRENT GAIN

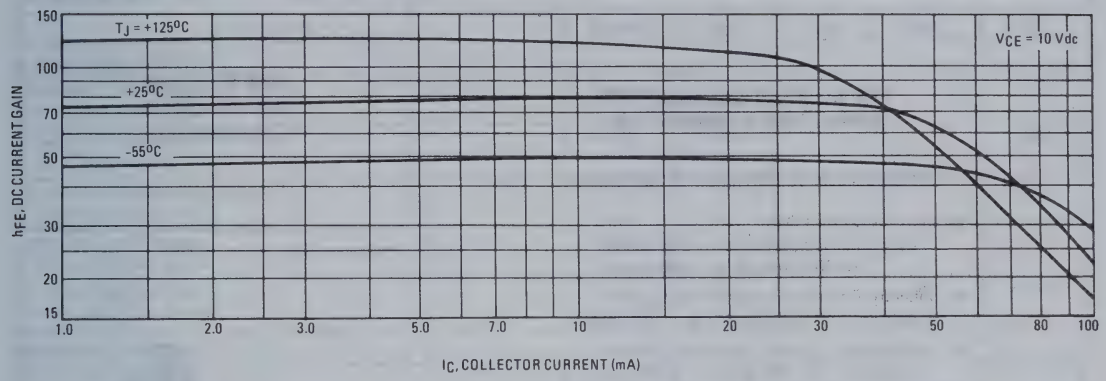


FIGURE 2 – CAPACITANCES

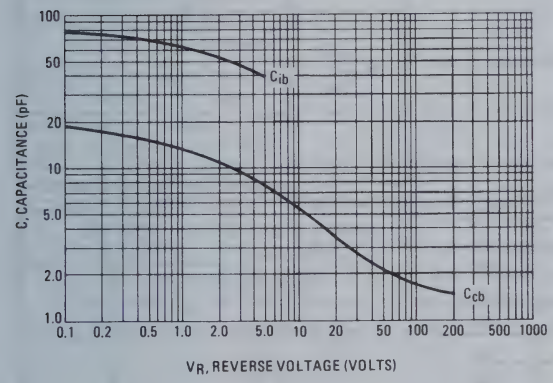


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

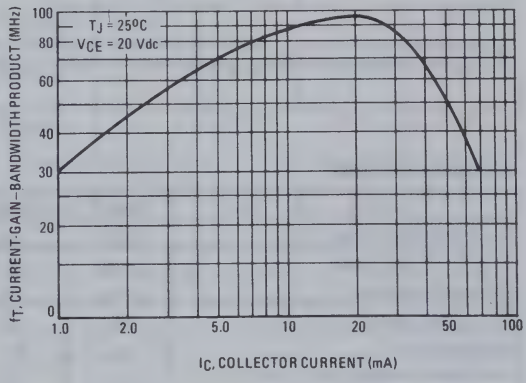


FIGURE 4 – "ON" VOLTAGES

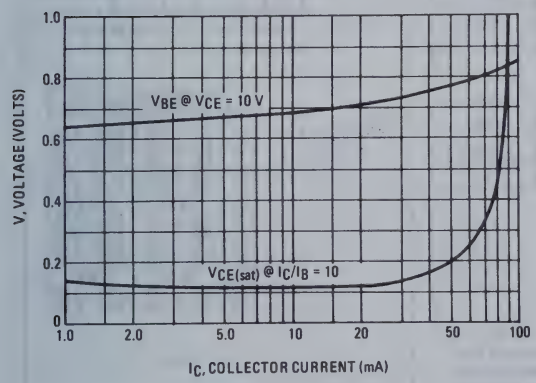
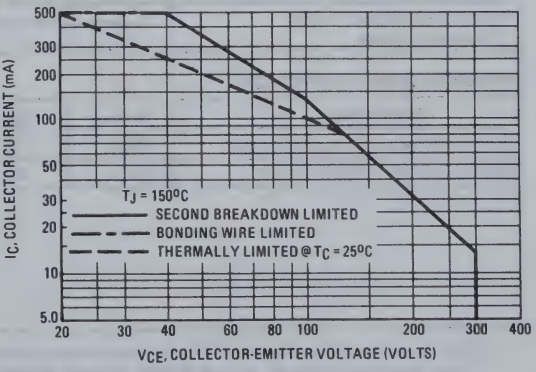


FIGURE 5 – DC SAFE OPERATING AREA



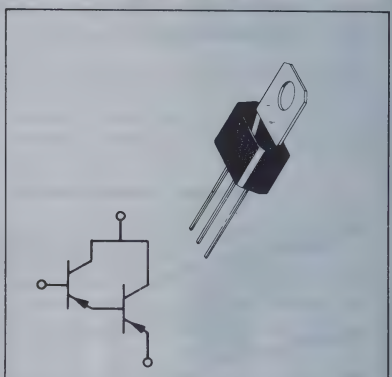
MPS-U95 (SILICON)

PNP SILICON DARLINGTON AMPLIFIER TRANSISTOR

. . . designed for amplifier and driver applications.

- High DC Current Gain –
  h_{FE} = 25,000 (Min) @ I_C = 200 mAdc
  15,000 (Min) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage –
  BV_{CES} = 40 Vdc (Min) @ I_C = 100 μAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc @ I_C = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to NPN MPS-U45

PNP SILICON DARLINGTON TRANSISTOR



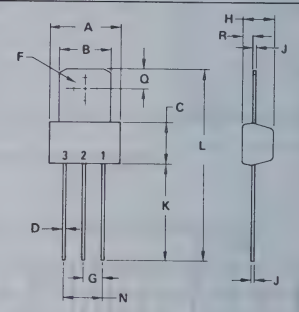
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}(1)	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	12	Vdc
Collector Current	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JA}$	12.5	°C/W

(1) Due to the monolithic construction of this device, breakdown voltages of both transistor elements are identical. BV_{CES} is tested in lieu of BV_{CEO} in order to avoid errors caused by noise pickup. The voltage measured during the BV_{CES} test is the BV_{CEO} of the output transistor.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	10	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 8.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)		25,000	65,000	150,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		15,000	35,000	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		4,000	12,000	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	1.2	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	1.85	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	1.7	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\|h_{fe}\|$	0.5	3.2	–	–
Collector Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	2.5	12	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Uniwatt darlington transistors can be used in any number of low power applications, such as relay drivers, motor control and as general purpose amplifiers. As an audio amplifier these devices, when used as a complementary pair, can drive 3.5 watts into a 3.2 ohm speaker using a 14 volt supply with less than one per cent distortion. Because of the high gain the base drive requirement is as low as 1 mA in this application. They are also useful as power drivers for high current application such as voltage regulators.

FIGURE 1 – DC CURRENT GAIN

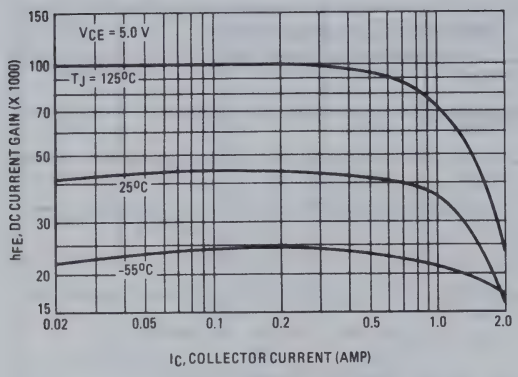


FIGURE 2 – SMALL-SIGNAL CURRENT GAIN

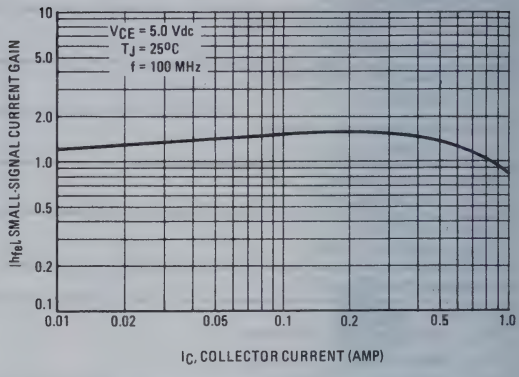


FIGURE 3 – "ON" VOLTAGES

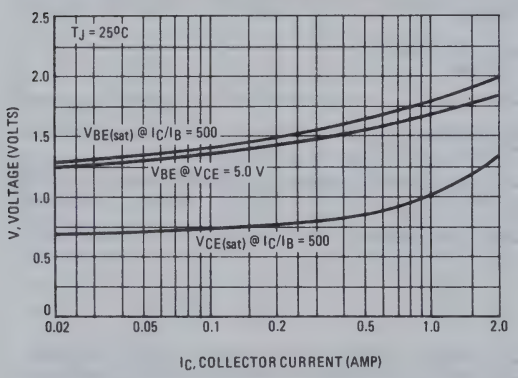


FIGURE 4 – TEMPERATURE COEFFICIENT

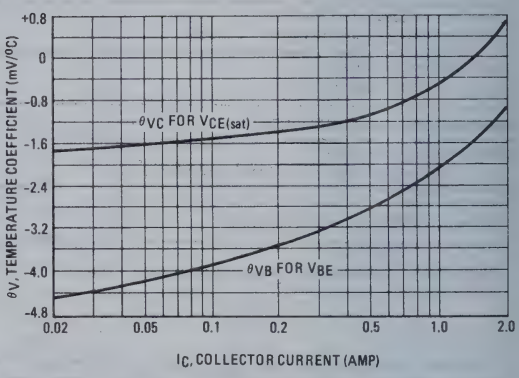
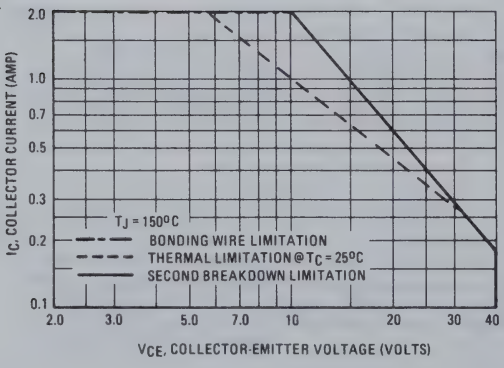


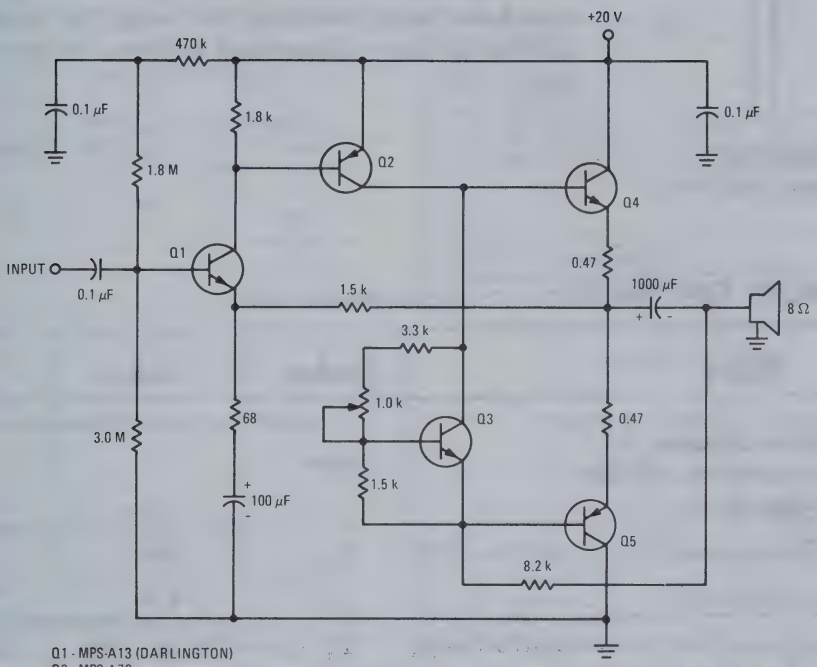
FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

5-WATT AUDIO AMPLIFIER



Q1 - MPS-A13 (DARLINGTON)
Q2 - MPS-A70
Q3 - MPS-A20
Q4 - MPS-U45 } COMPLEMENTARY
Q5 - MPS-U95 } DARLINGTONS

MPT20 (SILICON)



CASE 182
(Formerly CASE 29 B)

Plastic silicon 3-layer bilateral triggers are two-terminal devices that exhibit bi-directional negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits for lamp drivers and universal motor speed controls.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C	P_D	300	mW
Derate above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Plastic Trigger (MPT) devices have bi-directional characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation. (See Figure 1)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (Switching) Voltage - both directions	$V_{(BR)12}$ & $V_{(BR)21}$	16	20	24	Volt
Breakover (Switching) Current - both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	35	100	μAmp
Switchback (Delta) Voltage - both directions ($I_{12} = I_{21}$ = 10 mAdc)	ΔV_{12} & ΔV_{21}	5.0	7.0	-	Volt
Peak Blocking Current - both directions Voltage Applied = 14 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – VOLT-AMPERE CHARACTERISTICS

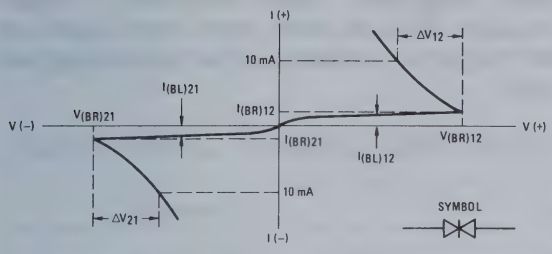


FIGURE 2 – INSTANTANEOUS "ON" VOLTAGE

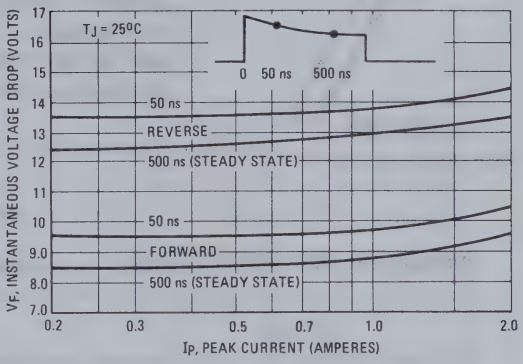


FIGURE 3 – BREAKOVER VOLTAGE BEHAVIOR

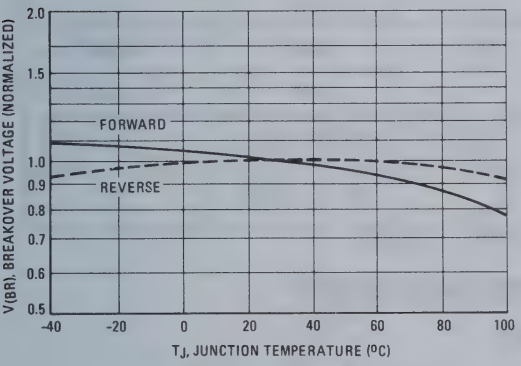


FIGURE 4 – NORMALIZED OUTPUT VOLTAGE BEHAVIOR

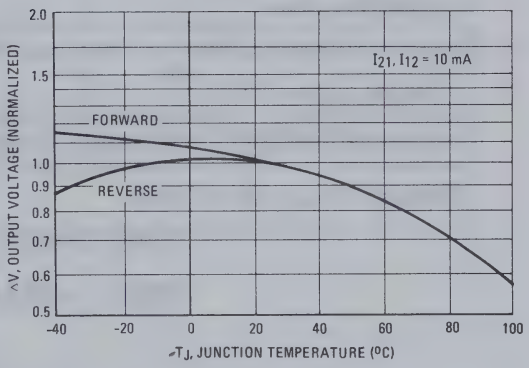


FIGURE 5 – SWITCHING TIMES

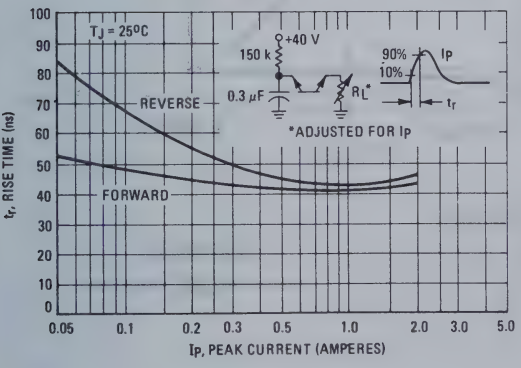
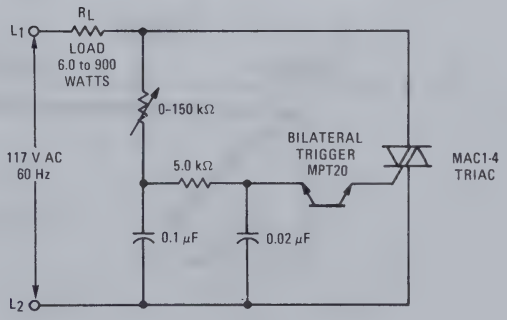


FIGURE 6 – CONTROL CIRCUIT



MPT28 (SILICON)
MPT32



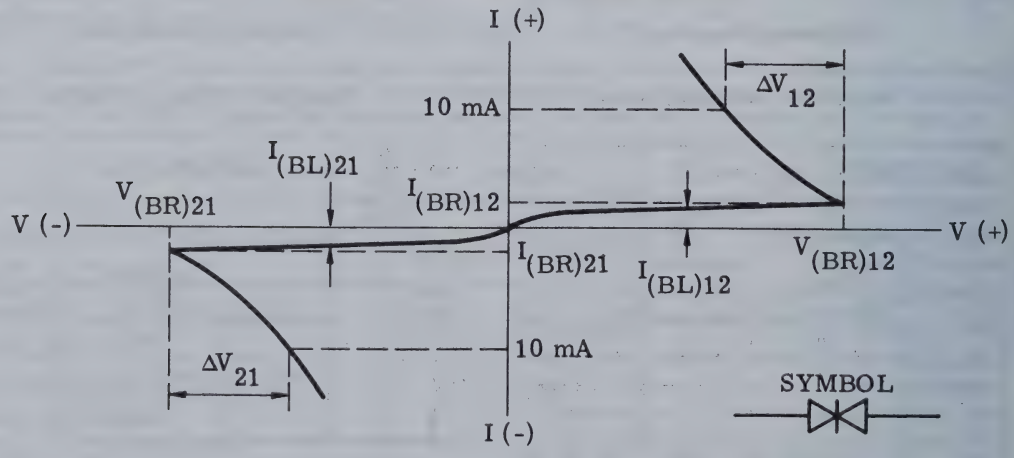
CASE 182
(Formerly CASE 29 B)

Plastic silicon annular 3-layer bilateral triggers, two-terminal devices which exhibit symmetrical negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits, signal switching and detection circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C	P_D	300	mW
Derate above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

FIGURE 1 — VOLT AMPERE CHARACTERISTICS

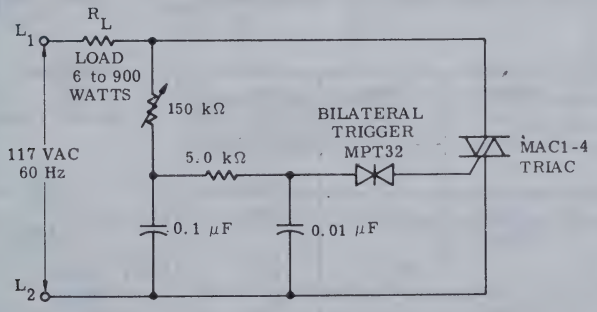


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

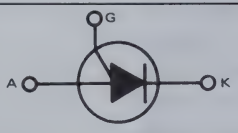
Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (switching) Voltage – both directions MPT28 MPT32	$V_{(BR)12}$ & $V_{(BR)21}$	 24 28	 28 32	 32 36	Volt
Breakover (switching) Current – both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	20	50	μAmp
Switchback (delta) Voltage – both directions MPT28 MPT32	ΔV_{12} & ΔV_{21}	 7.0 7.0	 10 10	 - -	Volt
Peak Blocking Current – both directions Voltage Applied = 18 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA
Breakover (switching) Voltage Temperature Coefficient, T_A = -40°C to +100°C		-	0.03	-	%/°C

Plastic trigger devices have symmetrical characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation.

FIGURE 2 — TYPICAL CONTROL CIRCUIT



MPU131 (SILICON)
thru
MPU133



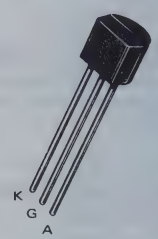
SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-trigger, oscillator, pulse and timing circuits. The MPU131, MPU132 and MPU133 may also be used in special thyristor applications due to the availability of an anode gate. Supplied in an inexpensive TO-92 plastic package for high-volume requirements, this package is readily adaptable for use in automatic insertion equipment.

- Programmable — R_{BB}, η, I_V and I_P.
- Low On-State Voltage — 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current — 5.0 nA Maximum
- High Peak Output Voltage — 11 Volts Typical
- Low Offset Voltage — 0.35 Volt Typical (R_G = 10 k ohms)

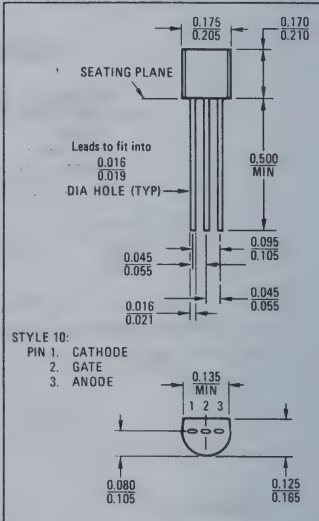
SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

40 VOLTS
375 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate Above 25°C	P_F $1/\theta_{JA}$	375 5.0	mW mW/°C
DC Forward Anode Current Derate Above 25°C	I_T	200 2.67	mA mA/°C
DC Gate Current	I_G	±20	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt
Operating Junction Temperature Range	T_J	-50 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



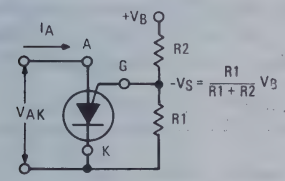
All JEDEC dimensions and notes apply

CASE 29-02
TO-92
PLASTIC

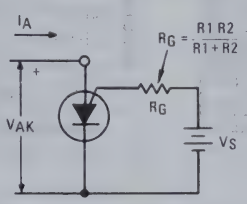
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Figure	Symbol	Min	Typ	Max	Unit
Peak Current	MPU131	2,9-14	I_P	–	1.25	2.0	μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU132			–	0.19	0.30	
	MPU133			–	0.08	0.15	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU131			–	4.0	5.0	
	MPU132			–	1.20	2.0	
	MPU133				0.70	1.0	
Offset Voltage	MPU131	1	V_T	0.2	0.70	1.6	Volts
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU132			0.2	0.50	0.6	
	MPU133			0.2	0.40	0.6	
(V_S = 10 Vdc, R_G = 10 k ohms) (All Types)				0.2	0.35	0.6	
Valley Current		1,4,5,	I_V				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU131, 132			–	18	50	
	MPU133			–	18	25	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU131			70	270	–	
	MPU132, 133			50	270	–	
Gate to Anode Leakage Current		–	I_{GAO}				nAdc
(V_S = 40 Vdc, T_A = 25°C, Cathode Open)				–	1.0	5.0	
(V_S = 40 Vdc, T_A = 75°C, Cathode Open)				–	30	75	
Gate to Cathode Leakage Current (V_S = 40 Vdc, Anode to Cathode Shorted)		–	I_{GKS}	–	5.0	50	nAdc
Forward Voltage (I_F = 50 mA Peak)		1,6	V_F	–	0.8	1.5	Volts
Peak Output Voltage (V_B = 20 Vdc, C_C = 0.2 μF)		3,7	V_o	6.0	11	–	Volts
Pulse Voltage Rise Time (V_B = 20 Vdc, C_C = 0.2 μF)		3	t_r	–	40	80	ns

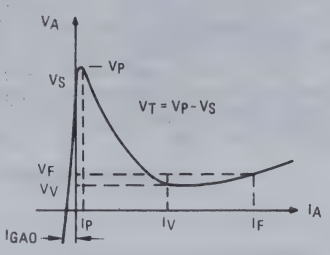
FIGURE 1 – ELECTRICAL CHARACTERIZATION



1A – PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2



1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)



1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (Ip) TEST CIRCUIT

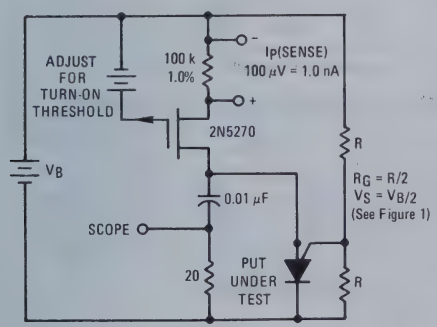
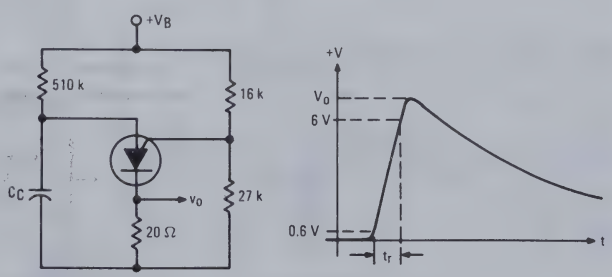


FIGURE 3 – V_o AND t_r TEST CIRCUIT



TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

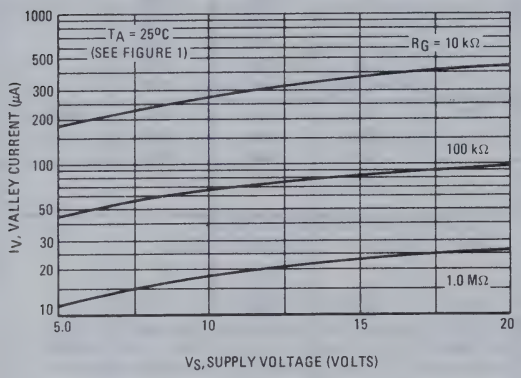


FIGURE 5 – EFFECT OF TEMPERATURE

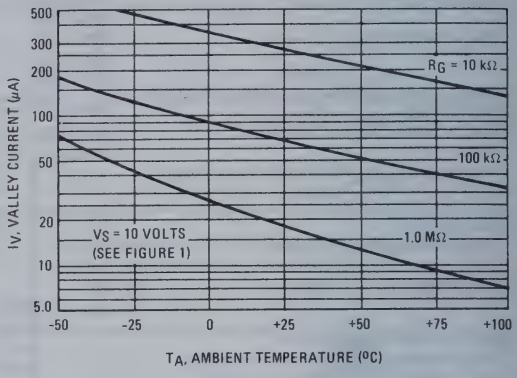


FIGURE 6 – FORWARD VOLTAGE

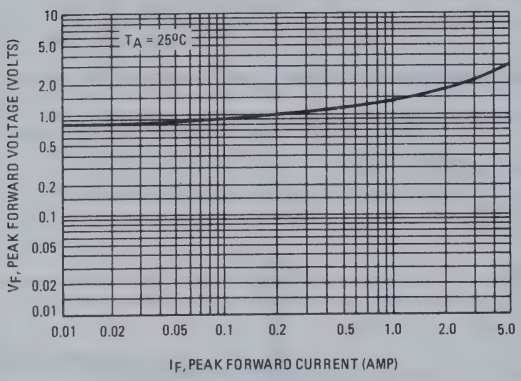


FIGURE 7 – PEAK OUTPUT VOLTAGE

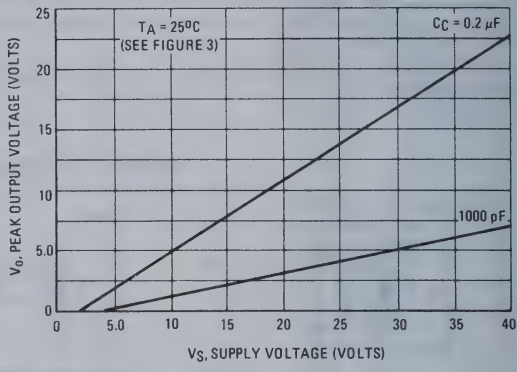
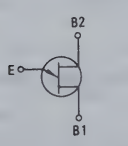
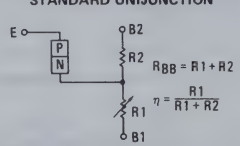


FIGURE 8 – STANDARD UNIJUNCTION COMPARED TO PROGRAMMABLE UNIJUNCTION

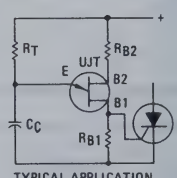
STANDARD UNIJUNCTION



CIRCUIT SYMBOL



EQUIVALENT CIRCUIT

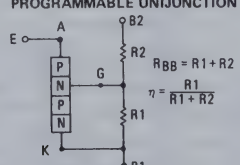


TYPICAL APPLICATION

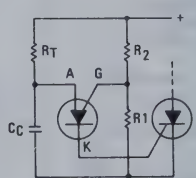
PROGRAMMABLE UNIJUNCTION



CIRCUIT SYMBOL



EQUIVALENT CIRCUIT
WITH EXTERNAL "PROGRAM"
RESISTORS R1 and R2



TYPICAL APPLICATION

TYPICAL PEAK CURRENT BEHAVIOR

MPU131

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

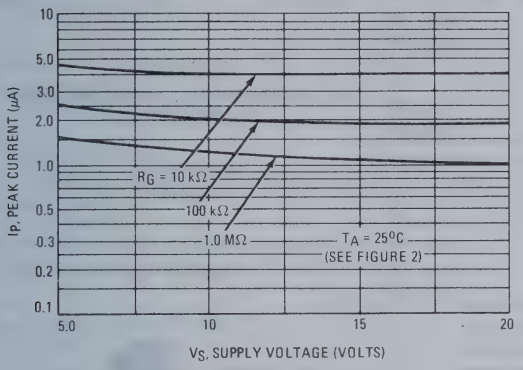
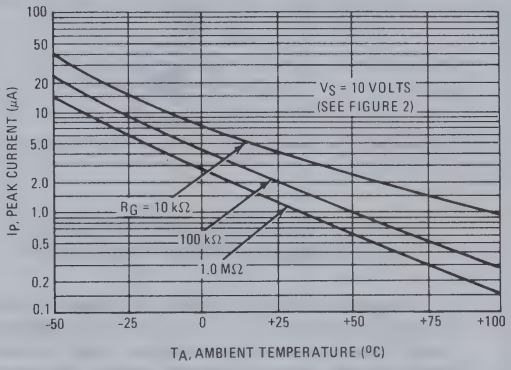


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



MPU132

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

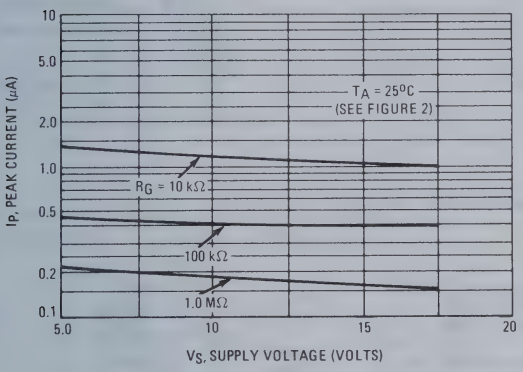
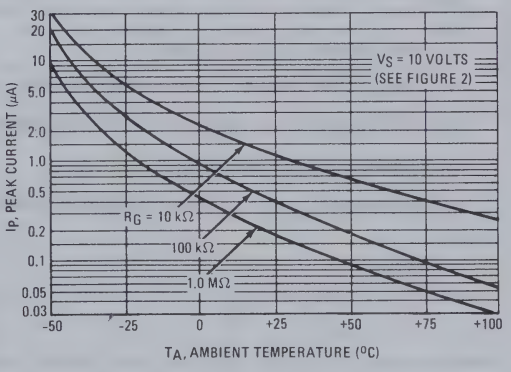


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



MPU133

FIGURE 13 – EFFECT OF SUPPLY VOLTAGE AND R_G

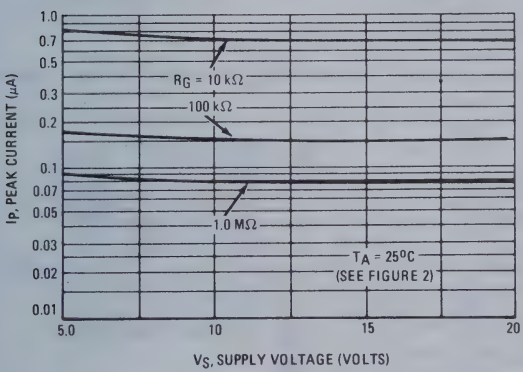
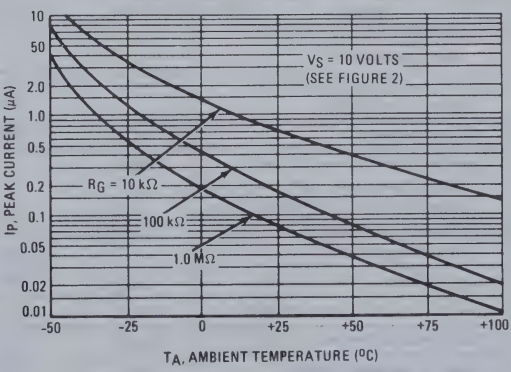
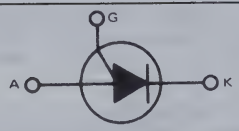


FIGURE 14 – EFFECT OF TEMPERATURE AND R_G



MPU6027, MPU6028 (SILICON)



SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

40 VOLTS
375 mW



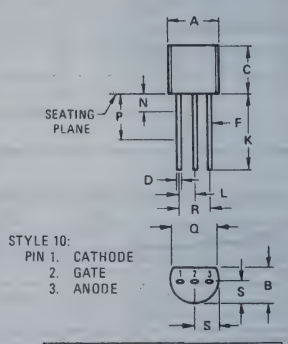
SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-trigger, oscillator, pulse and timing circuits. These devices may also be used in special thyristor applications due to the availability of an anode gate. Supplied in an inexpensive TO-92 plastic package for high-volume requirements, this package is readily adaptable for use in automatic insertion equipment.

- Programmable – R_{BB}, η, I_V and I_P.
- Low On-State Voltage – 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current – 10 nA Maximum
- High Peak Output Voltage – 11 Volts Typical
- Low Offset Voltage – 0.35 Volt Typical (R_G = 10 k ohms)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation (1) Derate Above 25°C	P_F $1/\theta_{JA}$	375 5.0	mW mW/°C
DC Forward Anode Current (2) Derate Above 25°C	I_T	200 2.67	mA mA/°C
DC Gate Current	I_G	±50	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	-5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt
Operating Junction Temperature Range	T_J	-50 to +100	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C



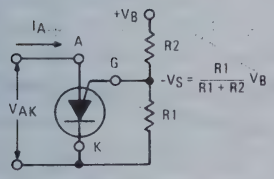
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	3.940	0.125	0.155
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.540 TP		0.100 TP	
S	2.030	2.670	0.080	0.105

CASE 29-03
TO-92

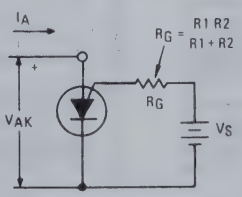
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Figure	Symbol	Min	Typ	Max	Unit
Peak Current		2,9,11	I_P				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			–	1.25	2.0	
	MPU6028			–	0.08	0.15	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU6027			–	4.0	5.0	
	MPU6028			–	0.70	1.0	
Offset Voltage		1	V_T				Volts
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			0.2	0.70	1.6	
	MPU6028			0.2	0.50	0.6	
(V_S = 10 Vdc, R_G = 10 k ohms)	(Both Types)			0.2	0.35	0.6	
Valley Current		1,4,5,	i_V				μA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			–	18	50	
	MPU6028			–	18	25	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU6027			70	270	–	
	MPU6028			25	270	–	
Gate to Anode Leakage Current		–	I_{GAO}				nAdc
(V_S = 40 Vdc, T_A = 25°C, Cathode Open)				–	1.0	10	
(V_S = 40 Vdc, T_A = 75°C, Cathode Open)				–	3.0	–	
Gate to Cathode Leakage Current (V_S = 40 Vdc, Anode to Cathode Shorted)		–	I_{GKS}	–	5.0	50	nAdc
Forward Voltage (I_F = 50 mA Peak)		1,6	V_F	–	0.8	1.5	Volts
Peak Output Voltage (V_B = 20 Vdc, C_C = 0.2 μF)		3,7	V_o	6.0	11	–	Volts
Pulse Voltage Rise Time (V_B = 20 Vdc, C_C = 0.2 μF)		3	t_r	–	40	80	ns

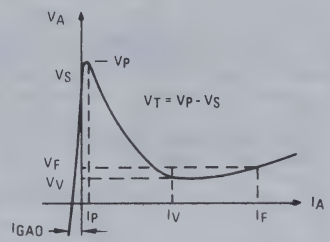
FIGURE 1 – ELECTRICAL CHARACTERIZATION



1A PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2



1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)



1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (I_P) TEST CIRCUIT

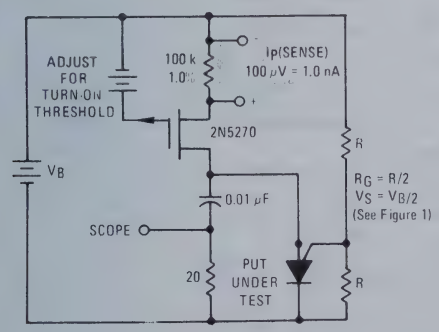
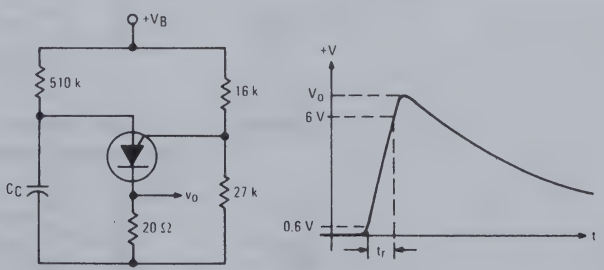


FIGURE 3 – V_o AND t_r TEST CIRCUIT



TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

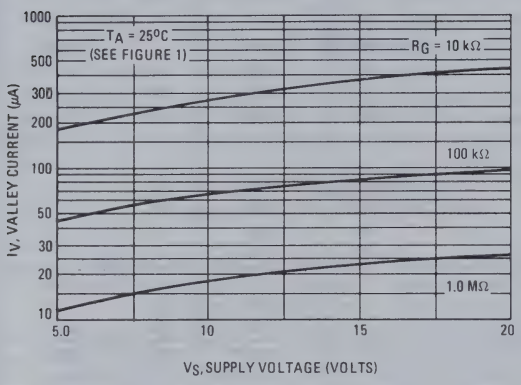


FIGURE 5 – EFFECT OF TEMPERATURE

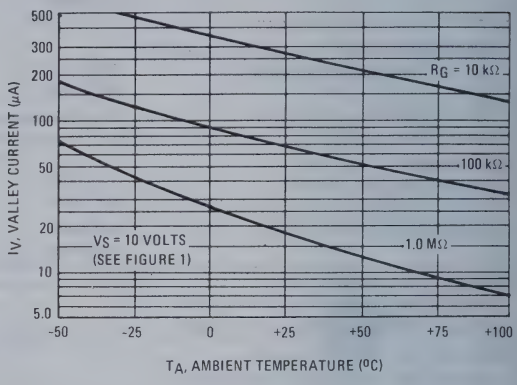


FIGURE 6 – FORWARD VOLTAGE

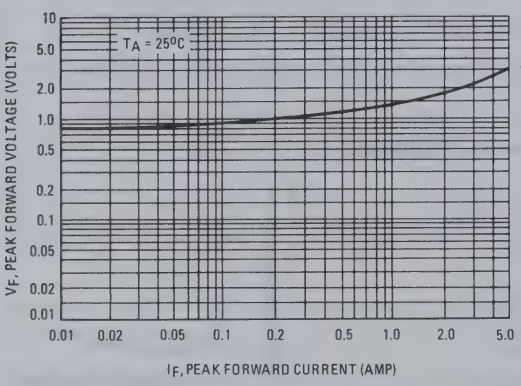


FIGURE 7 – PEAK OUTPUT VOLTAGE

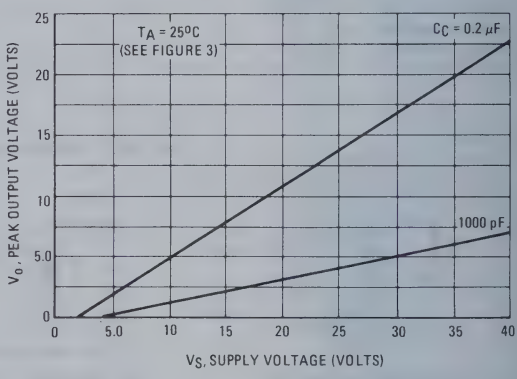
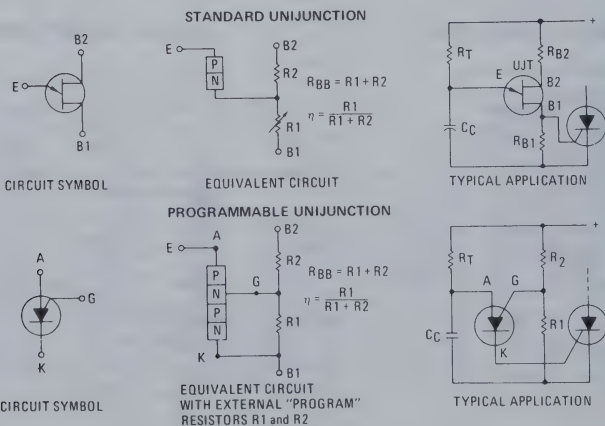


FIGURE 8 – STANDARD UNIJUNCTION
COMPARED TO PROGRAMMABLE UNIJUNCTION



TYPICAL PEAK CURRENT BEHAVIOR

MPU6027

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

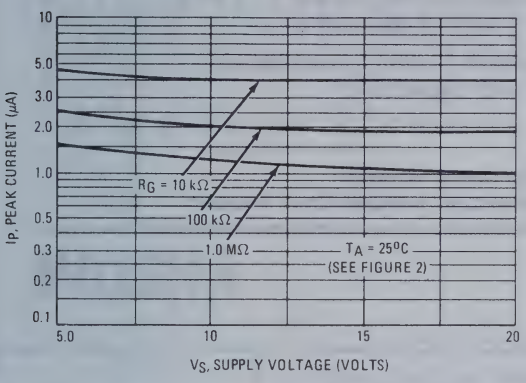
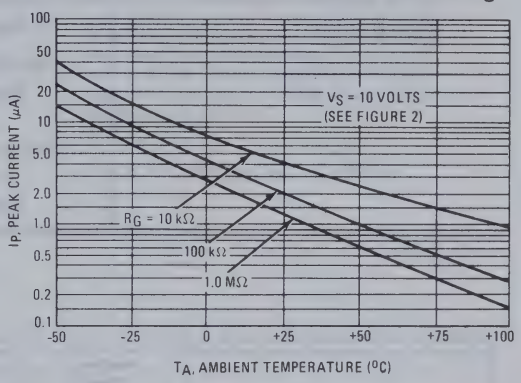


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



MPU6028

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

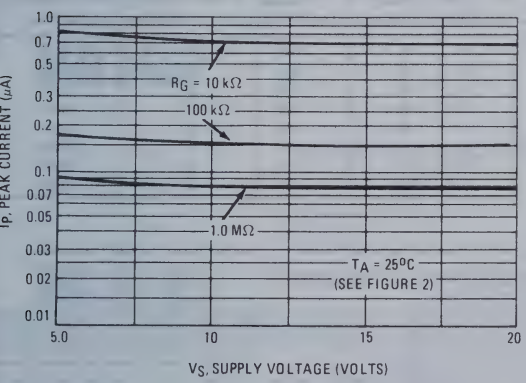
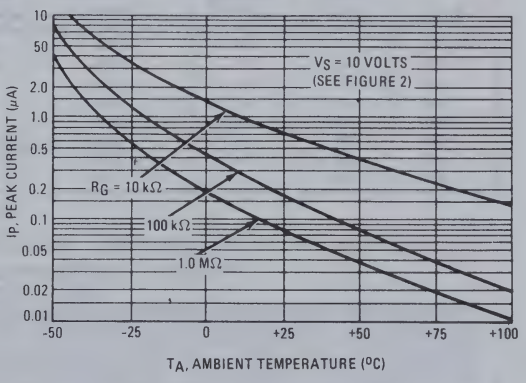
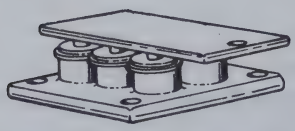


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



MPZ5-16 series (SILICON)
MPZ5-32 series
MPZ5-180 series

Silicon power transient suppressor designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Individual cells are matched to insure current-sharing under high current pulse conditions.



CASE 119

MAXIMUM RATINGS

Transient Power Dissipation: 40 kW
Pulse Width: 0.1 ms, (See Figure 1)

DC Power Dissipation: 350 Watts @ $T_C = 25°C$
(Derate 2.33 W/°C above 25°C)

Operating Junction & Storage Temperature Range: -65°C to +175°C

Polarity:
Anode-to-Case is Standard
Cathode-to-Case Available Upon Request

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$) ($V_F = 1.5$ V max @ 10 A for all types)

Type	Nominal Operating Voltage (Note 1) $V_{OP(PK)}$ Vdc	Nominal Operating Voltage (Note 1) $V_{OP(RMS)}$ V rms	Maximum Device Clamping Factor $CF = \frac{V_Z @ I_Z (pulse)}{V_Z @ I_{ZT}}$ (Note 2)	Minimum Zener Voltage $V_{Z(min)}$ Vdc @ I_{ZT} Adc	Maximum Zener Voltage Pulse Width = 1.0 ms $V_{Z(max)}$ Vdc @ $I_{Z(pulse)}$ Adc	Maximum Reverse Current $I_R(max)$ @ $V_R = V_{OP(PK)}$ μAdc	Typical Capacitance C (typ) @ $V_R = V_{OP(PK)}$ μF
MPZ5-16A	14	10	1.25	16 @ 0.4	24 @ 200	50	0.025
-16B	14	10	1.25	16 @ 0.4	20 @ 200	▲	0.025
-32A	28	20	1.25	32 @ 0.2	50 @ 100	▲	0.011
-32B	28	20	1.25	32 @ 0.2	45 @ 100	▲	0.011
-32C	28	20	1.25	32 @ 0.2	40 @ 100	▲	0.011
-180A	165	117	1.14	180 @ 0.03	250 @ 20	▲	0.0012
-180B	165	117	1.14	180 @ 0.03	225 @ 20	▲	0.0012
-180C	165	117	1.14	180 @ 0.03	205 @ 20	50	0.0012

FIGURE 1 – MAXIMUM NON-REPETITIVE SURGE POWER
(RECTANGULAR WAVEFORM)

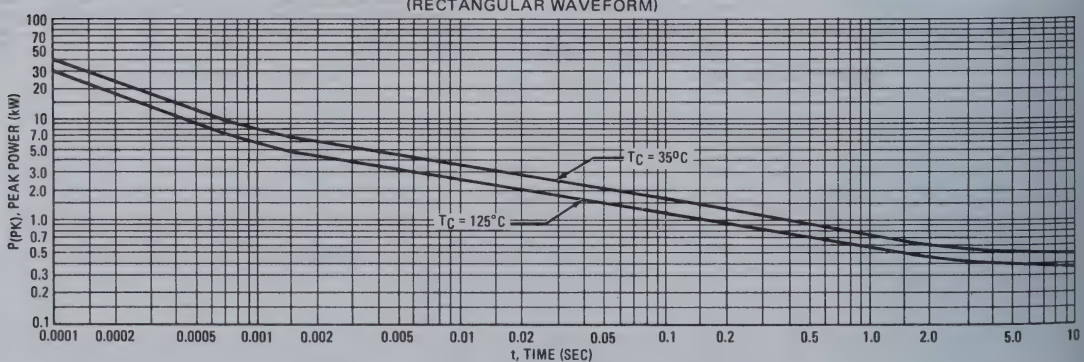
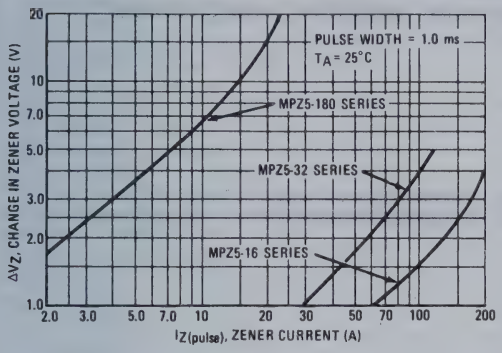


FIGURE 2 – TYPICAL DYNAMIC ZENER VOLTAGE CHARACTERISTICS (Note 2)



NOTE 1: Nominal operating voltage is defined as normal input voltage to device for non-operating condition. If non-sinusoidal wave or dc input is present, peak voltage input values $V_{OP(PK)}$ should be used to select device type.

NOTE 2: The maximum device clamping factor C_F is a ratio of V_Z measured at I_Z (pulse) given in the Electrical Characteristics Table divided by V_Z measured at I_{ZT} under steady state conditions. This value guarantees the sharpness of the voltage breakdown of individual devices. Figure 2 demonstrates the typical sharpness of the breakdown, and indicates the voltage regulation over a wide range of currents.

$$\Delta V_Z = V_Z @ I_{Z(pulse)} - V_Z @ I_{ZT}$$

MQ2219A

For Specifications, See MD2219 Data.

MQ3467

For Specifications, See MD3467 Data.

MQ3725

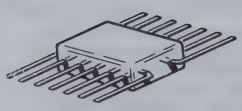
For Specifications, See MD3725 Data.

MQ3762

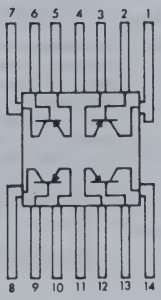
For Specifications, See MD3762 Data.

MQ3799 (SILICON)

Quad PNP silicon annular transistor specifically designed for differential amplifier applications.



CASE 607
(TO-86)



Lead 1 identified by color dot or by elbow on lead. All leads electrically isolated from package.

MAXIMUM RATINGS (each transistor)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D	250	500	mW
Derate above 25°C		1.5	2.85	mW/°C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	90	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	-	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		-	-	10	
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	-	-	20	nAdc

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		225	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		300	-	900	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)		300	-	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		300	-	900	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		-	-	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		-	-	0.25	
Base-Emitter Saturation Voltage (1)	$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		-	-	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		-	-	0.8	
Base-Emitter On Voltage	$V_{BE(on)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		-	-	0.7	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product	f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		100	-	500	
Output Capacitance	C_{ob}				pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		-	-	4.0	
Input Capacitance	C_{ib}				pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		-	-	8.0	
Input Impedance	h_{ie}				k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		-	12	-	
Voltage Feedback Ratio	h_{re}				X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		-	2.5	-	
Small-Signal Current Gain	h_{fe}				-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		-	500	-	
Output Admittance	h_{oe}				μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		-	12	-	
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz)		-	2.5	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz)		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, Noise Bandwidth = 10 Hz to 15.7 kHz)		-	1.5	-	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE

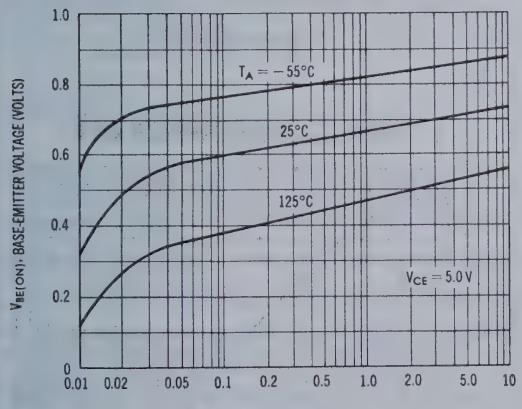


FIGURE 2 — NOISE FIGURE versus FREQUENCY AND SOURCE RESISTANCE

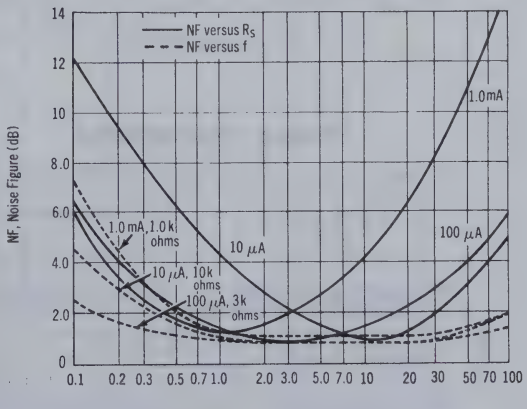
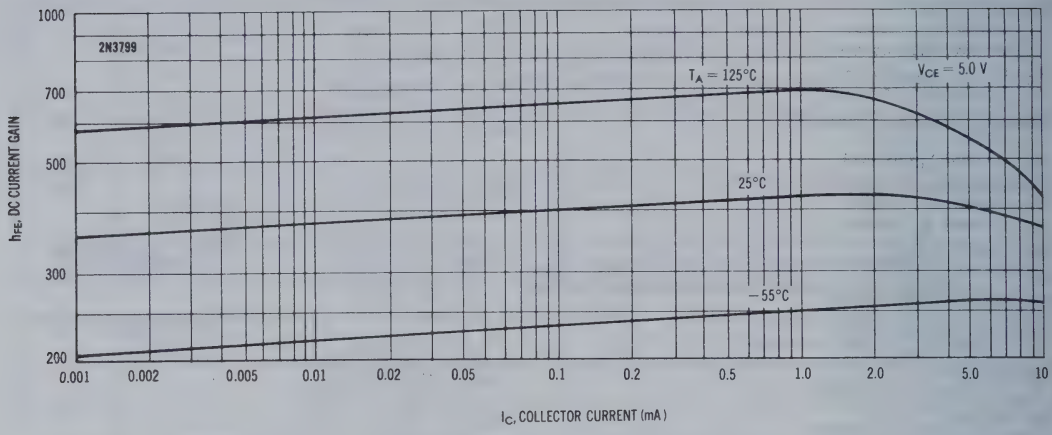


FIGURE 3 — TYPICAL CURRENT GAIN CHARACTERISTICS



SMALL SIGNAL h PARAMETERS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 4 — CURRENT GAIN

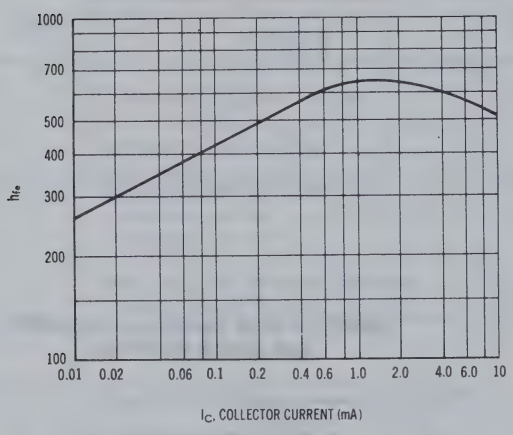


FIGURE 5 — OUTPUT ADMITTANCE

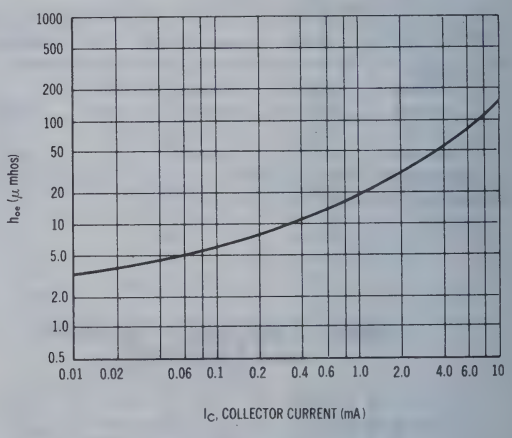


FIGURE 6 — INPUT IMPEDANCE

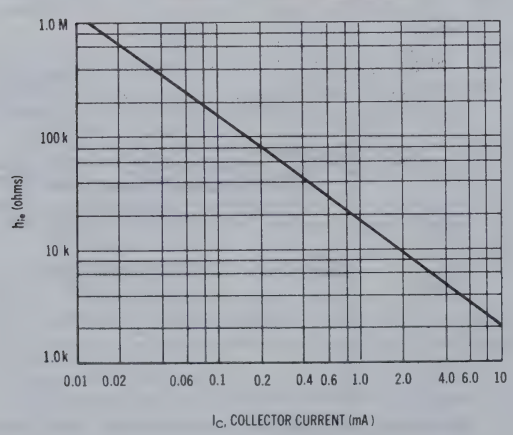
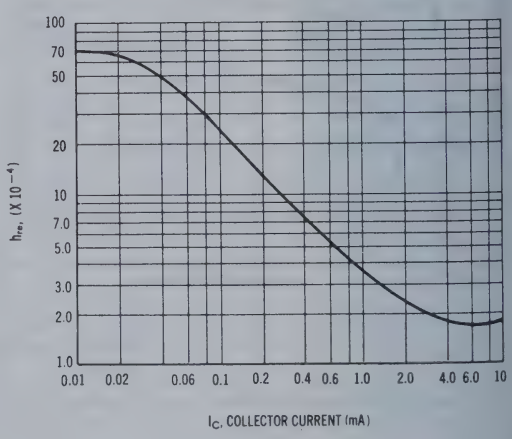


FIGURE 7 — VOLTAGE FEEDBACK RATIO



MR1-1200 (SILICON)
MR1-1400
MR1-1600

AXIAL LEAD SILICON RECTIFIERS

. . . designed for television "damper" diode service and other high voltage industrial/consumer applications.

- High Current Handling — 1.0 Ampere at 75°C
- Medium Recovery Characteristics
- Low Forward Voltage

HIGH VOLTAGE LEAD MOUNTED SILICON RECTIFIERS

1200, 1400, 1600, VOLTS
1 AMPERE



MAXIMUM RATINGS

Rating	Symbol	MR1-1200	MR1-1400	MR1-1600	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	1200	1400	1600	Volts
Average Rectified Forward Current (Single phase, resistive load, $R_{\theta JA}$ = 85°C/W, T_A = 75°C) (1)	I_O	1.0			Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions.)	I_{FSM}	30 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (2)	T_J,T_{stg}	-65 to +175			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

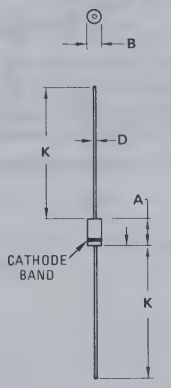
Characteristic	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (i_F = 1.0 Amp, T_J = 25°C) (i_F = 3.14 Amp, T_J = 25°C)	v_F	 0.95 1.1	 1.1 1.3	Volts
Maximum Reverse Current (rated dc voltage) T_J = 25°C T_J = 100°C	I_R	 0.2 12	 10 100	μA
Capacitance (V_R = 50 volts, f = 1.0 MHz)	C	4.0	7.0	pF
Reverse Recovery Time (I_F = 20 mA, I_R = 2.0 mA)	t_{rr}	17	25	μs
Forward Recovery Time (I_F = 20 mA, V_{fr} = 2.0 V)	t_{fr}	0.7	1.0	μs

(1) Must be derated for reverse power dissipation. See note on Page 3.

(2) Derate as shown in Figure 4.

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds at 5 lbs. tension
FINISH: All external surfaces are corrosion-resistant, leads are readily solderable
POLARITY: Cathode indicated by color band
WEIGHT: 0.40 Grams (approximately)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	5.20	0.185	0.205
B	2.54	2.71	0.100	0.107
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-01
CONFORMS TO DO-41

FIGURE 1 – FORWARD POWER DISSIPATION

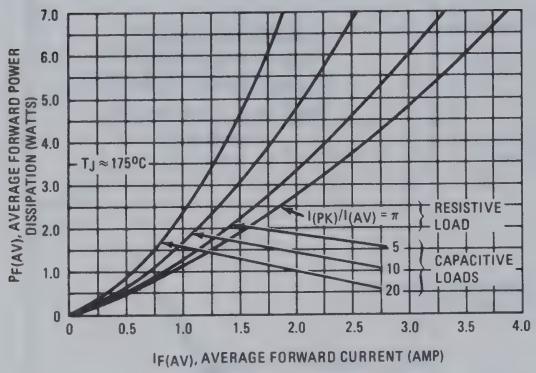


FIGURE 2 – CURRENT DERATING

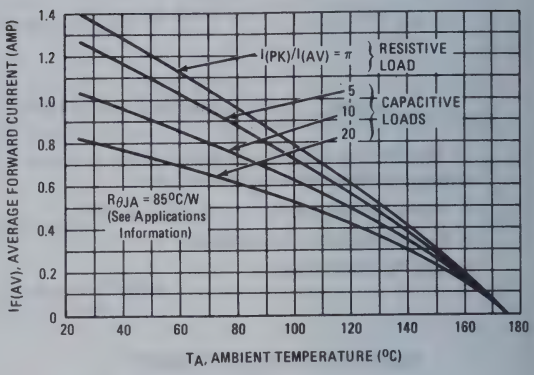


FIGURE 3 – NON-REPETITIVE SURGE CURRENT

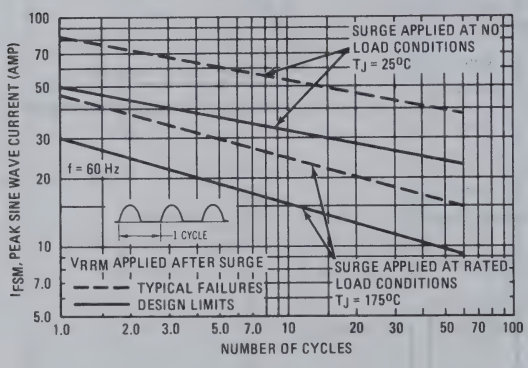
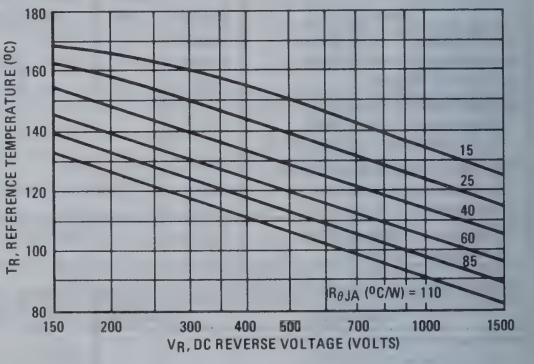


FIGURE 4 – MAXIMUM REFERENCE TEMPERATURE

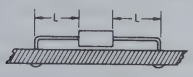


APPLICATIONS INFORMATION

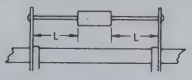
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)			
	1/32	3/8	1	$R_{\theta JA}$
1	–	60	85	°C/W
2	73	85	103	°C/W

MOUNTING METHOD 1
P.C. Board with 1½" x 1½" copper surface



MOUNTING METHOD 2
Vector Push-In Terminals T-28



Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 50 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 4 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 175°C when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 4 as a difference in the rate of change of the slope in the vicinity of 160°C. The data of Figure 4 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design: i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR1-1200 operated in a 500 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that I_{DC} = 1.0 A, ($I_{F(AV)}$ = 0.5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 353 V(rms) (line to center tap), $R_{\theta JA}$ = 60°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1.
$V_{R(equiv)}$ = 1.41) (353) (1.11) = 555 V

Step 2: Find T_R from Figure 4. Read T_R = 117°C @ V_R = 555 V @ $R_{\theta JA}$ = 60°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 1. Read $P_{F(AV)}$ = 0.6 W @ $\frac{I_{PK}}{I_{AV}}$ = 10 & $I_{F(AV)}$ = 0.5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 117 -(60) (0.6) = 81°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$ †Use line to center tap voltage for V_{in}

MR322 thru MR326
MR327, MR328, MR330, MR331

For Specifications, See 1N3491 Data, Volume 1.

MR501, MR502, MR504
MR506, MR508, MR510

Designers Data Sheet

MINIATURE SIZE, AXIAL LEAD MOUNTED STANDARD RECOVERY POWER RECTIFIERS

. . . designed for use in power supplies and other applications having need of a device with the following features:

- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Void-Free Economical Plastic Package
- Available in Volume Quantities

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

STANDARD RECOVERY POWER RECTIFIERS

100-1000 VOLTS
3 AMPERE



MAXIMUM RATINGS

Rating	Symbol	MR 501	MR 502	MR 504	MR 506	MR 508	MR 510	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	150	250	450	650	850	1050	Volts
Average Rectified Forward Current (Single phase resistive load, T_A = 95°C, PC Board Mounting) (1) (EIA Standard Conditions L = 1/32", T_L = 85°C)	I_O	3.0 8.0						Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	100 (one cycle)						Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	-65 to +175						°C

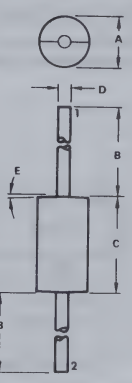
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 2 on Page 4).	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (3) (i_F = 9.4 Amp, T_J = 175°C) (i_F = 9.4 Amp, T_J = 25°C)	v_F	– –	0.9 1.04	1.0 1.1	Volts
Reverse Current (rated dc voltage) (3) T_J = 25°C T_J = 100°C	I_R	– –	0.1 2.8	5.0 25	μA

(1) Derate for reverse power dissipation. See Note on Page 2.
(2) Derate as shown in Figure 1.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



	MILLIMETERS		INCHES	
A	4.83	5.33	0.190	0.210
B	26.97	27.23	1.062	1.072
C	9.40	9.65	0.370	0.380
D	1.22	1.32	0.048	0.052
E	2°		2°	

CASE 267

MECHANICAL CHARACTERISTICS

Case: Void Free, Transfer Molded
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 200 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 1 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where $T_J = 175°C$, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 1 as a difference in the rate of change of the slope in the vicinity of 165°C. The data of Figure 1 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR510 operated in a 400 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that $I_{DC} = 6.0$ A, ($I_{F(AV)} = 3.0$ A), $I_{(PK)}/I_{(AV)} = 10$, Input Voltage = 283 V(rms) (line to center tap), $R_{\theta JA} = 28°C/W$.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1 ∴
$V_{R(equiv)} = 1.41(283)(1.11) = 444$ V

Step 2: Find T_R from Figure 1. Read $T_R = 167°C$ @ $V_R = 444$ V & $R_{\theta JA} = 28°C/W$.

Step 3: Find $P_{F(AV)}$ from Figure 8. Read $P_{F(AV)} = 4$ W
@ $\frac{I_{PK}}{I_{AV}} = 10$ & $I_{F(AV)} = 3.0$ A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)} = 167-(28)(4) = 55°C$.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$ †Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE

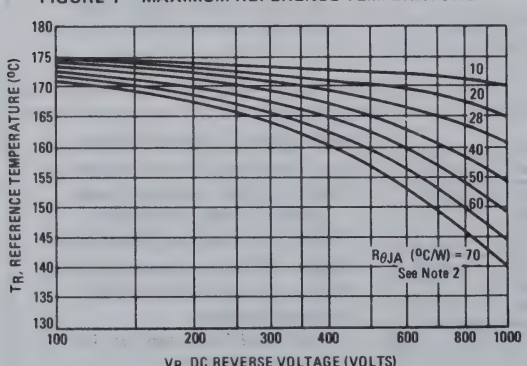
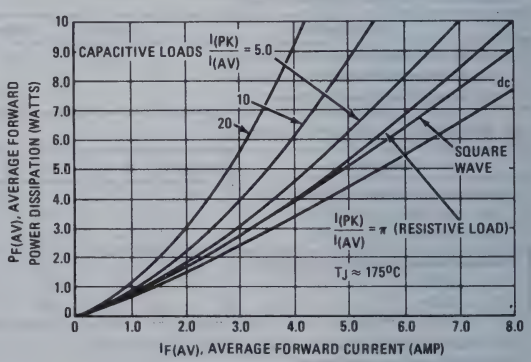


FIGURE 2 – FORWARD POWER DISSIPATION



CURRENT DERATING
(Reverse Power Loss Neglected)

FIGURE 3 – PC BOARD MOUNTING

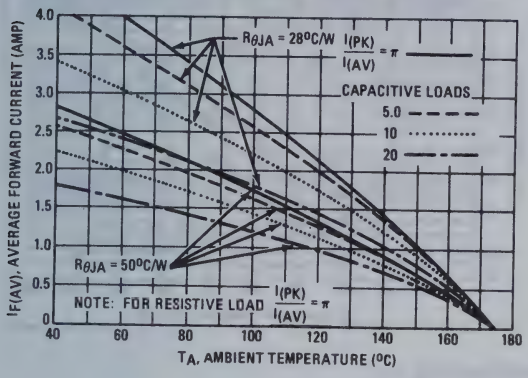


FIGURE 4 – SEVERAL LEAD LENGTHS

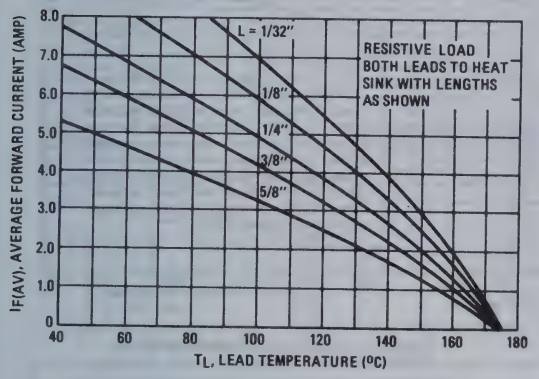


FIGURE 5 – 1/8" LEAD LENGTH

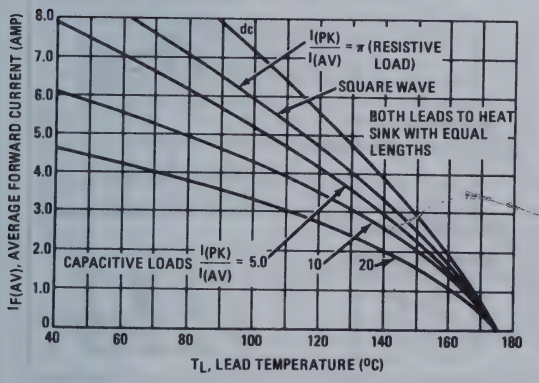


FIGURE 6 – FORWARD VOLTAGE

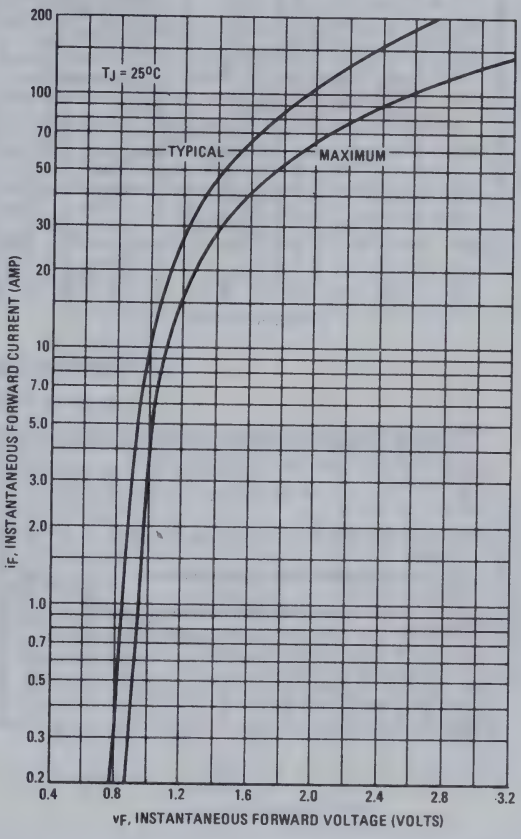


FIGURE 7 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

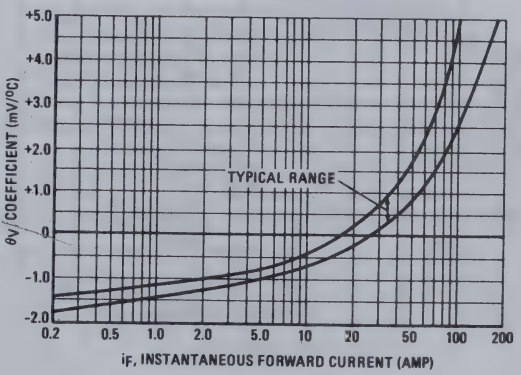


FIGURE 8 – MAXIMUM SURGE CAPABILITY

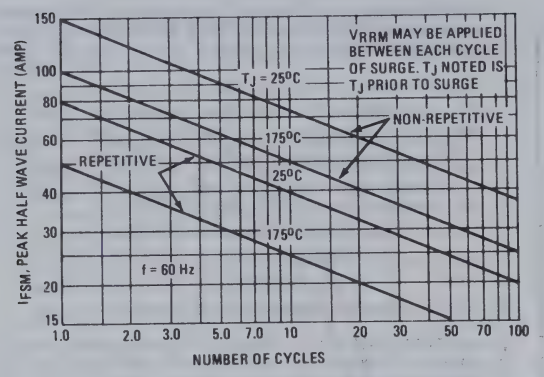
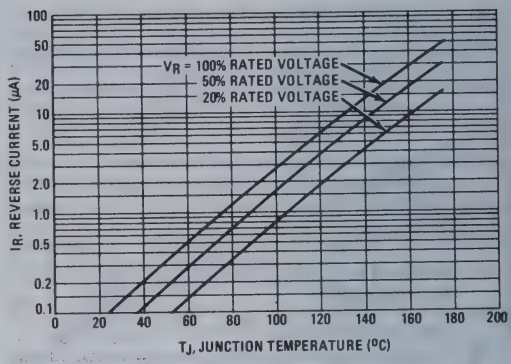


FIGURE 9 – TYPICAL REVERSE CURRENT



THERMAL CHARACTERISTICS

FIGURE 10 – THERMAL RESPONSE

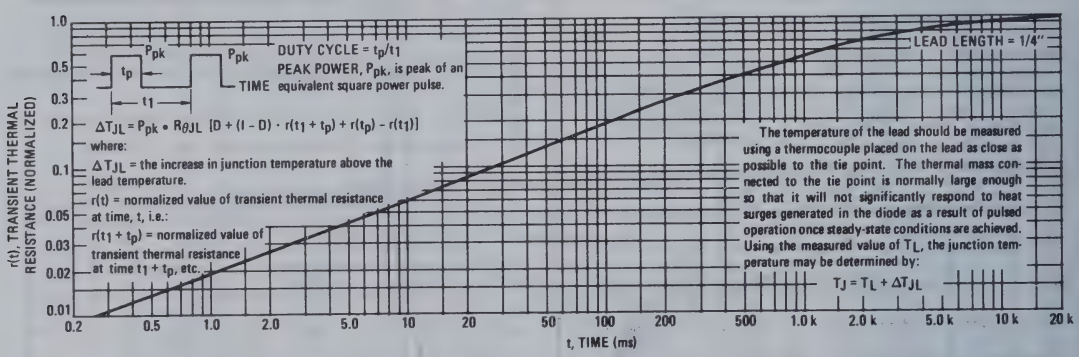
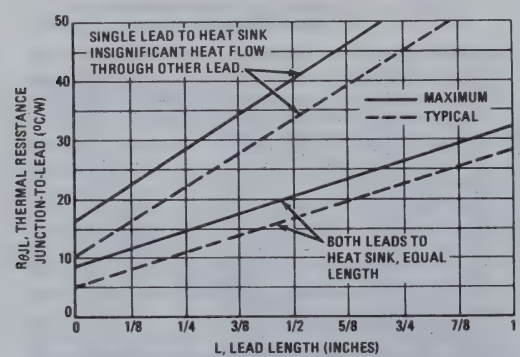


FIGURE 11 – STEADY-STATE THERMAL RESISTANCE



NOTE 2 – AMBIENT MOUNTING DATA

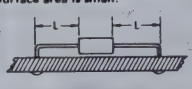
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

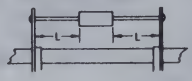
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



MOUNTING METHOD 2

Vector Push-In Terminals T-28



MOUNTING METHOD 3

P.C. Board with 1-1/2" x 1-1/2" Copper Surface

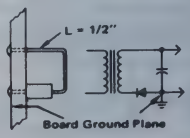
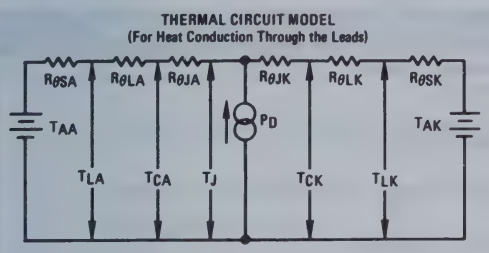


FIGURE 12 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.)
Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

$$T_L = T_{J(max)} - \Delta T_{JL}$$

where $\Delta T_{JL} \approx R_{\theta JL}$

TYPICAL DYNAMIC CHARACTERISTICS
(T_J = 25°C)

FIGURE 13 – FORWARD RECOVERY TIME

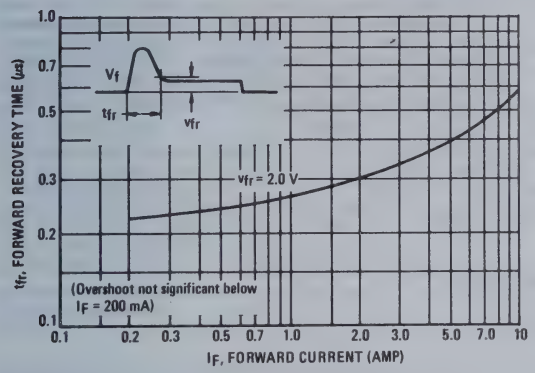


FIGURE 14 – REVERSE RECOVERY TIME

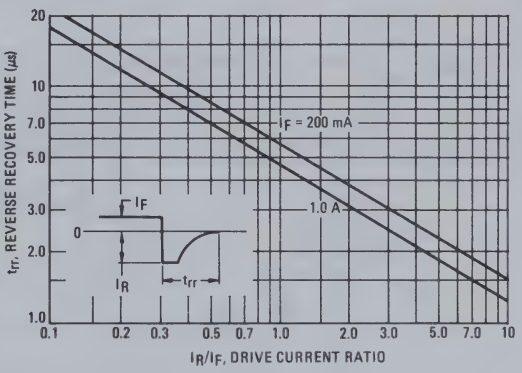


FIGURE 15 – RECTIFICATION WAVEFORM EFFICIENCY

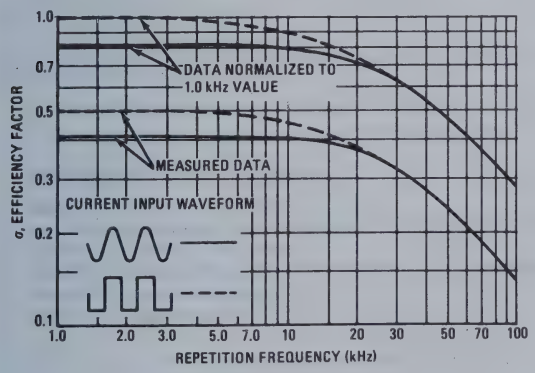
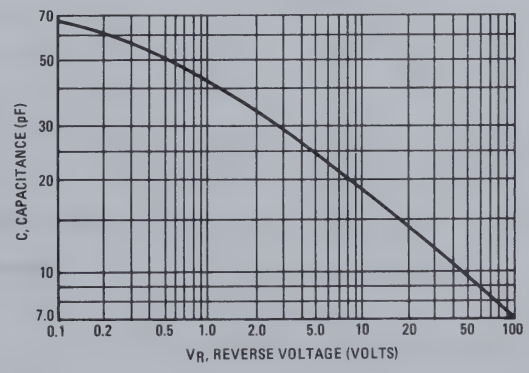
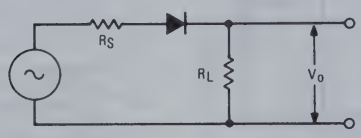


FIGURE 16 – JUNCTION CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 17 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 15 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\frac{V^2_{o(dc)}}{R_L}}{\frac{V^2_{o(rms)}}{R_L}} \cdot 100\% = \frac{V^2_{o(dc)}}{V^2_{o(ac)} + V^2_{o(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2_m}{2R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 14) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 15.

It should be emphasized that Figure 15 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the figure.

MR751 (SILICON)
MR752
MR754
MR756

Designers Data Sheet

HIGH CURRENT LEAD MOUNTED RECTIFIERS

- Current Capacity Comparable To Chassis Mounted Rectifiers
- Very High Surge Capacity
- Insulated Case

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

HIGH CURRENT LEAD MOUNTED SILICON RECTIFIERS

100–600 VOLTS DIFFUSED JUNCTION

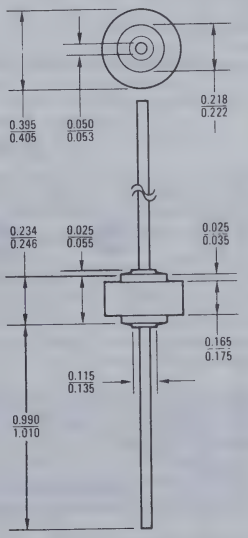


MAXIMUM RATINGS

Characteristic	Symbol	MR751	MR752	MR754	MR756	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	V_{RSM}	120	240	480	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	70	140	280	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz.) See Figures 5 and 6	I_O	22(T_L = 60°C, 1/8" Lead Lengths) 6.0(T_A = 60°C, P.C. Board mounting)				Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	400 (for 1 cycle)				Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175				°C

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (I_F = 100 Amp, T_J = 25°C)	v_F	1.25	Volts
Maximum Forward Voltage Drop (I_F = 6.0 Amp, T_A = 25°C, 3/8 inch leads)	V_F	0.90	Volts
Maximum Reverse Current (rated dc voltage) T_J = 25°C T_J = 100°C	I_R	0.25 1.0	mA



To convert inches to millimeters multiply by 25.4

CASE 194

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C 3/8" from case for 10 seconds at 5.0 lbs. tension

FINISH: All external surfaces are corrosion-resistant, leads are readily solderable

POLARITY: Indicated by diode symbol

WEIGHT: 2.5 Grams (approx)

FIGURE 1 – FORWARD VOLTAGE

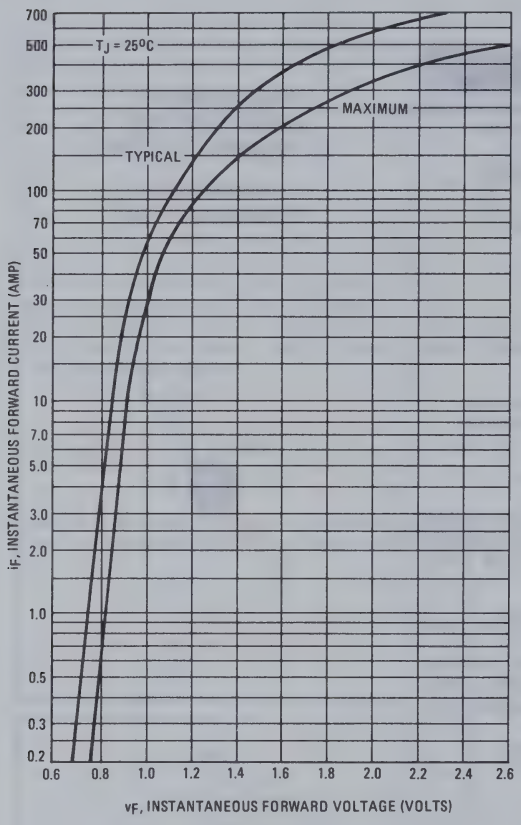


FIGURE 2 – MAXIMUM SURGE CAPABILITY

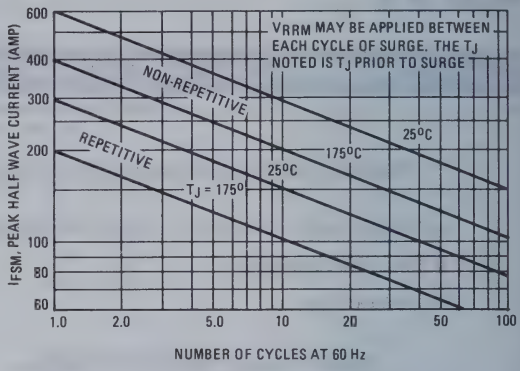


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

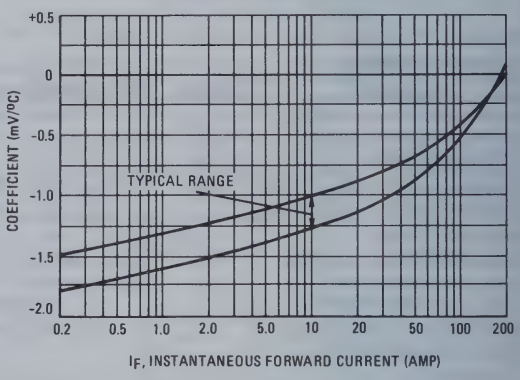


FIGURE 4 – TYPICAL TRANSIENT THERMAL RESISTANCE

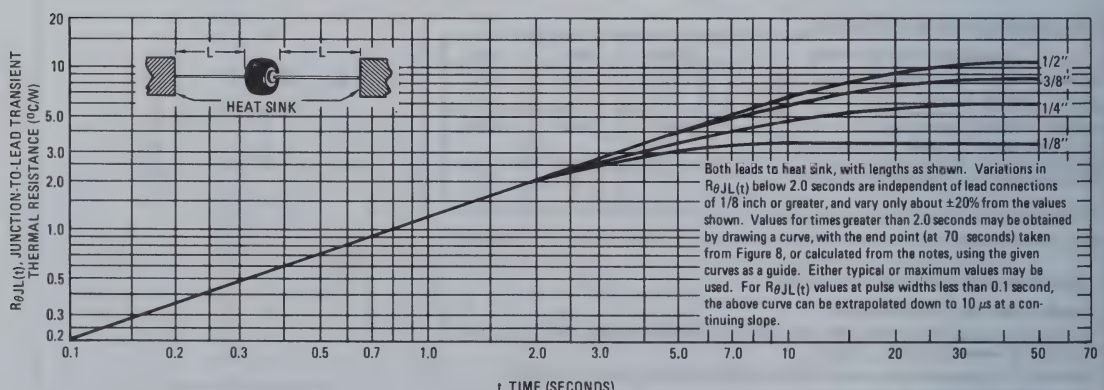


FIGURE 5 – MAXIMUM CURRENT RATINGS

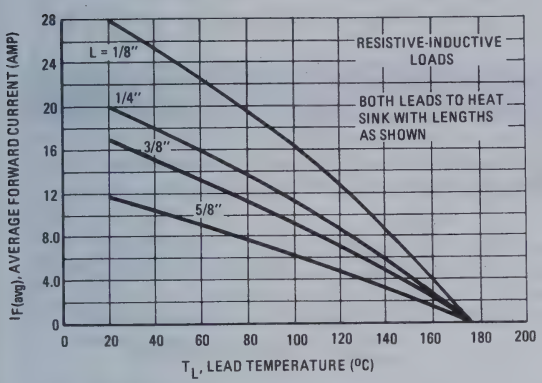


FIGURE 6 – MAXIMUM CURRENT RATINGS

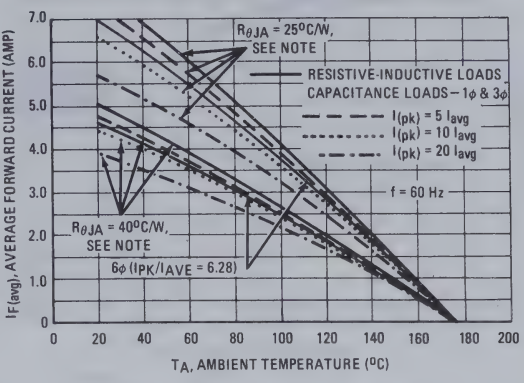


FIGURE 7 – POWER DISSIPATION

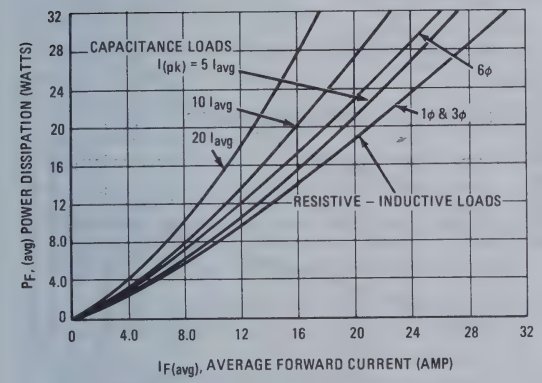
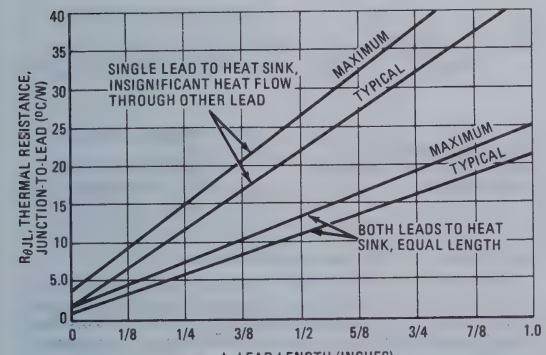
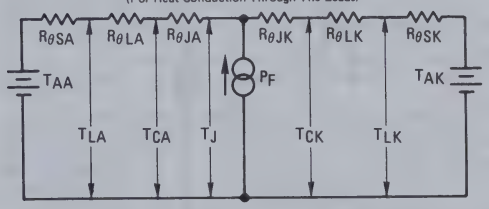


FIGURE 8 – STEADY STATE THERMAL RESISTANCE



NOTES

THERMAL CIRCUIT MODEL
(For Heat Conduction Through The Leads)



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. Terms in the model signify:

T_A = Ambient Temperature — $R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
T_L = Lead Temperature — $R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
T_C = Case Temperature — $R_{\theta J}$ = Thermal Resistance, Junction to Case
T_J = Junction Temperature — P_F = Power Dissipation
(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are:
$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AVG)}$. Therefore maximum lead temperature may be found from: $T_L = 175° - R_{\theta JL} P_F$. P_F may be found from Figure 7.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2" x 1-1/2" copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 9 – RECTIFICATION EFFICIENCY

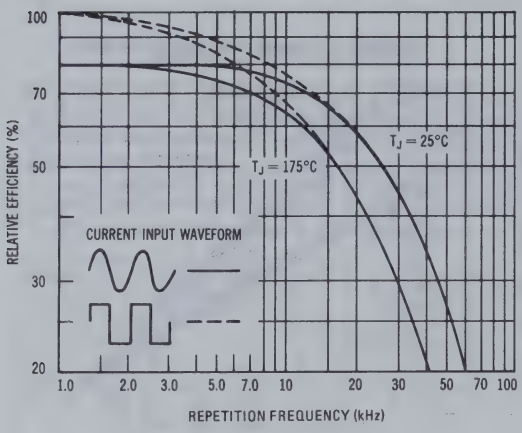


FIGURE 10 – REVERSE RECOVERY TIME

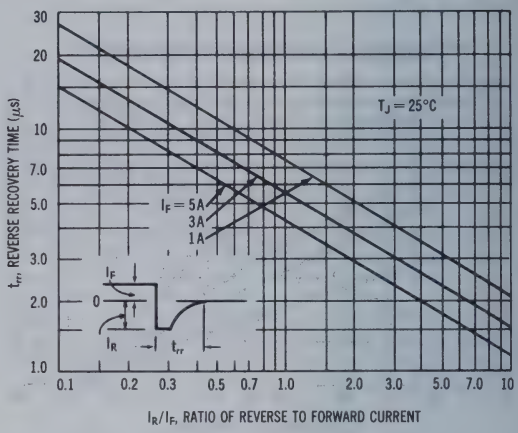


FIGURE 11 – JUNCTION CAPACITANCE

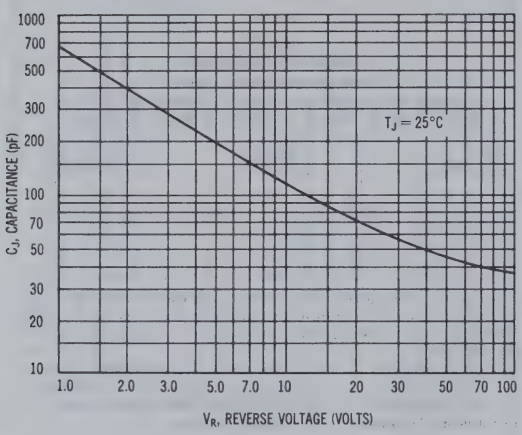


FIGURE 12 – FORWARD RECOVERY TIME

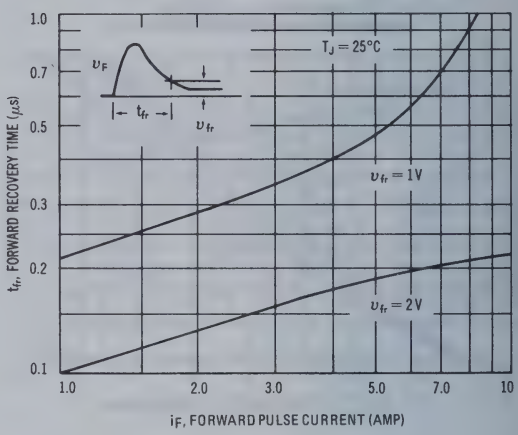
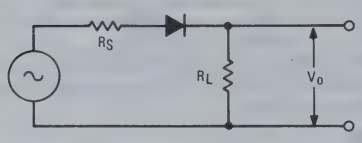


FIGURE 13 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 9 was calculated using the formula:

$$\sigma = \frac{P(dc)}{P(rms)} = \frac{\frac{V^2_o(dc)}{R_L}}{\frac{V^2_o(rms)}{R_L}} \cdot 100\% = \frac{V^2_o(dc)}{V^2_o(ac) + V^2_o(dc)} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma(\text{sine}) = \frac{\frac{V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma(\text{square}) = \frac{\frac{V^2_m}{2R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 10) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 9.

It should be emphasized that Figure 9 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 9.

MR810 thru MR814
MR816 thru MR818

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 200 nanoseconds providing high efficiency at frequencies to 250 kHz.

DESIGNER'S DATA FOR "WORST CASE" CONDITIONS

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing device characteristic boundaries — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR810	MR811	MR812	MR813	MR814	MR816	MR817	MR818	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	100	200	300	400	500	800	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	560	700	Volts
Average Rectified Forward Current (Single phase, resistive load, T_A = 75°C)	I_O	1.0								Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions) (T_A = 75°C)	I_{FSM}	30								Amps
Operating Junction Temperature Range	T_J	-65 to +150								°C
Storage Temperature Range	T_{stg}	-65 to +175								°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Typical Primted Circuit Board Mounting)	$R_{\theta JA}$	65	°C/W

ELECTRICAL CHARACTERISTICS

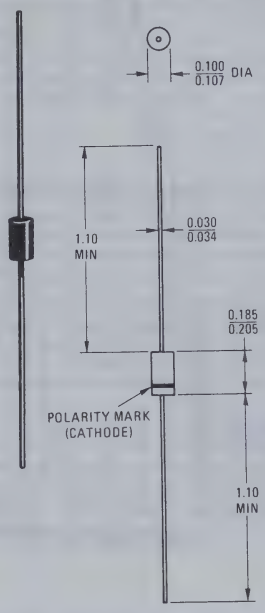
Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 3.14 Amp, T_J = 150°C)	v_F	–	1.1	1.2	Volts
Forward Voltage (I_F = 1.0 Amp, T_A = 25°C)	V_F	–	1.0	1.1	Volts
Reverse Current (rated dc voltage) T_A = 25°C T_A = 100°C	I_R	– –	1.0 50	10 100	μA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc) (Figure 21) (I_F = 20 mA, I_R = 2.0 mA, Tektronix S-Plug-In) (Figure 22)	t_{rr}	– –	200 1.0	750 3.0	ns μs
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc) (Figure 21)	$I_{RM(REC)}$	–	–	3.0	Amp

FAST RECOVERY POWER RECTIFIERS

50-1000 VOLTS
1 AMPERE



All JEDEC dimensions and notes apply

CASE 59
DO-41

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded

FINISH: External leads are gold plated, leads are readily solderable

POLARITY: Cathode indicated by Polarity band

WEIGHT: 0.4 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

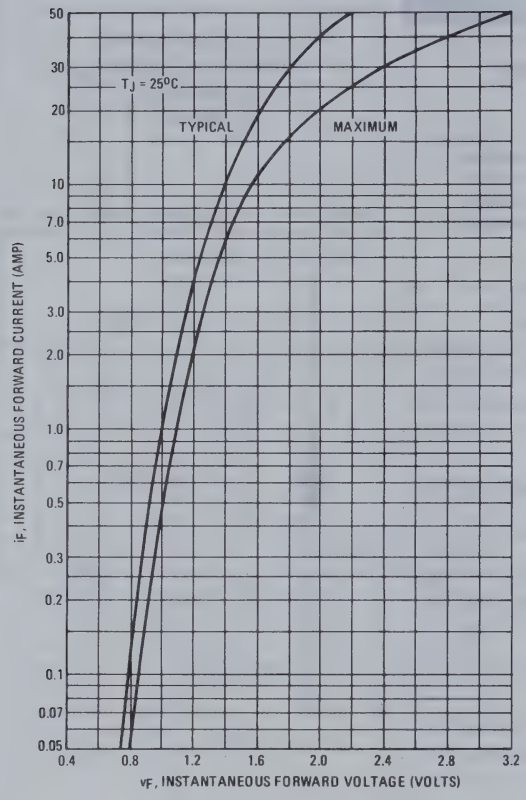


FIGURE 2 – MAXIMUM SURGE CAPABILITY

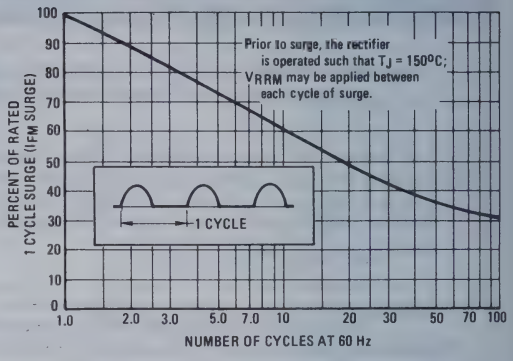


FIGURE 3 – TEMPERATURE COEFFICIENT

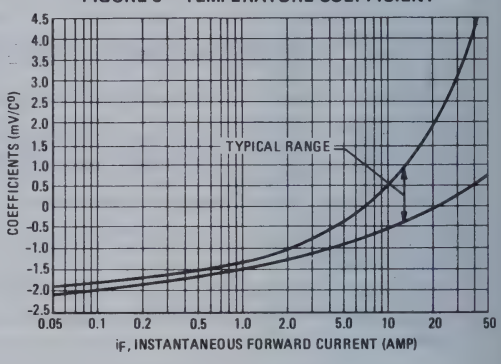


FIGURE 4 – FORWARD POWER DISSIPATION

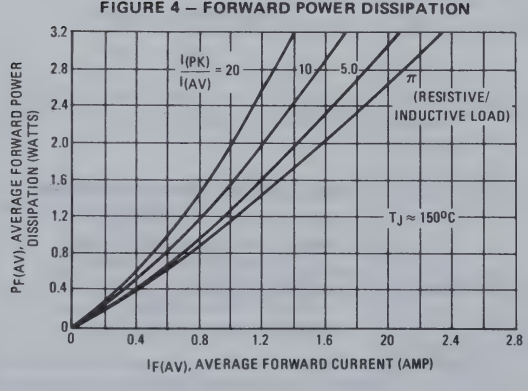
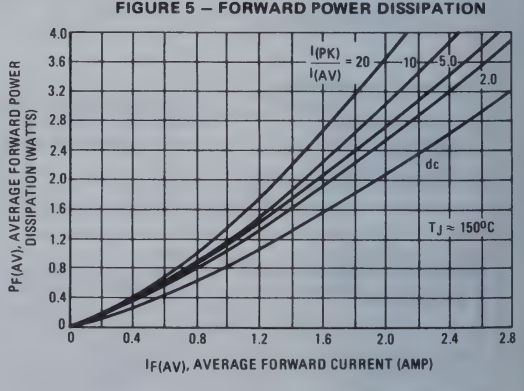


FIGURE 5 – FORWARD POWER DISSIPATION



MAXIMUM CURRENT RATINGS
(SEE NOTES 1 and 2)

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

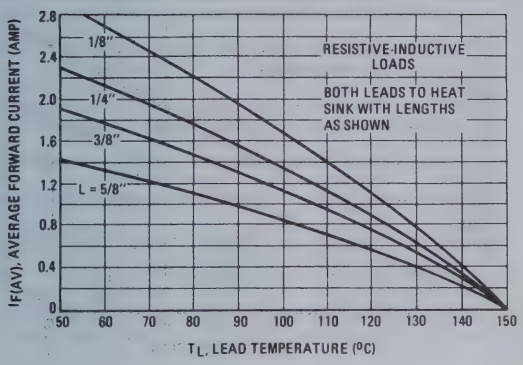


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

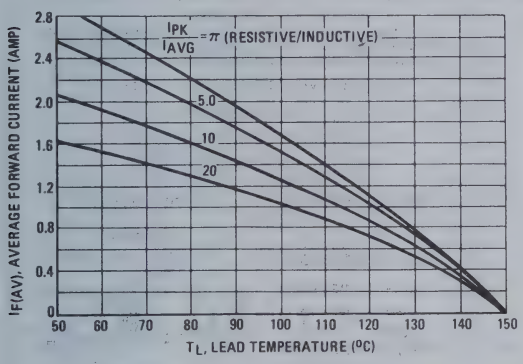
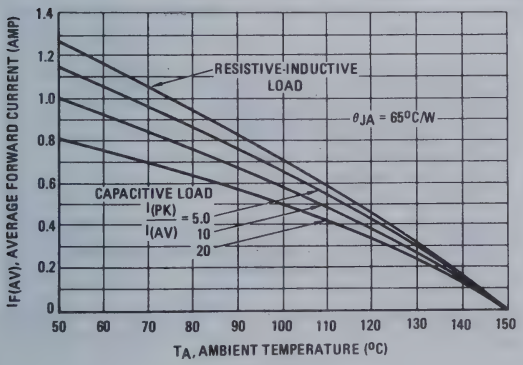


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

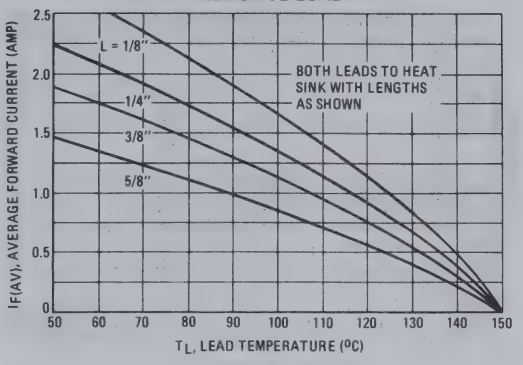


FIGURE 9 – 1/8" LEAD LENGTH, VARIOUS LOADS

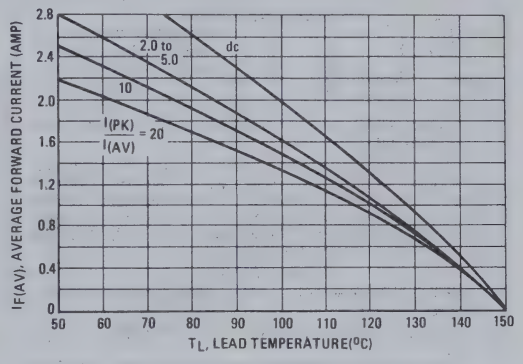


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

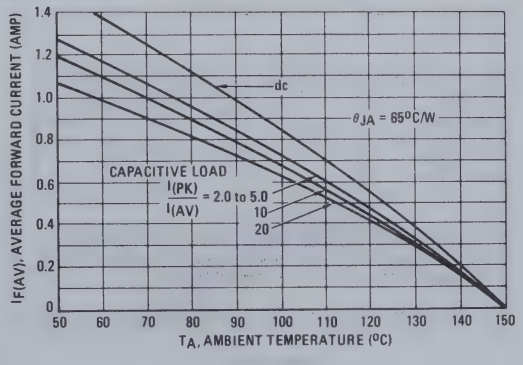


FIGURE 12 – THERMAL RESPONSE

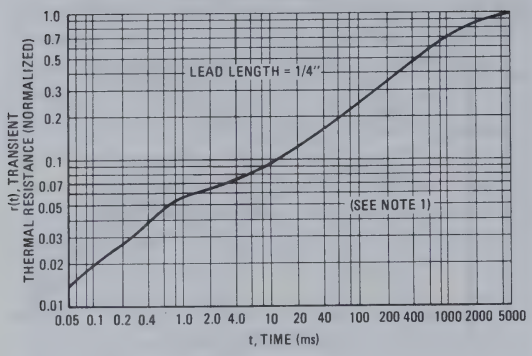
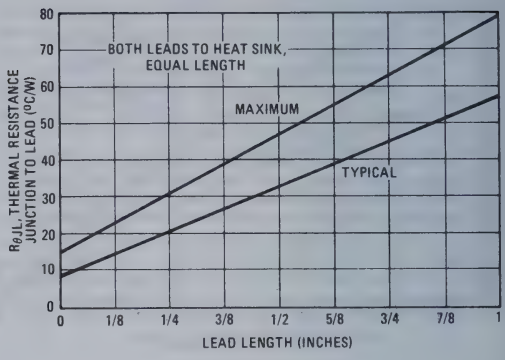
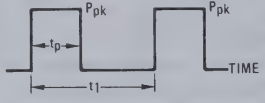


FIGURE 13 – THERMAL RESISTANCE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC}\left[D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)\right]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 12, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

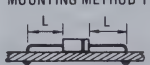
NOTE 2

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR θ_{JA} IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	65	72	82	92	°C/W
2	74	81	91	101	°C/W
3	40				°C/W

MOUNTING METHOD 1



MOUNTING METHOD 2



Vector pin mounting

MOUNTING METHOD 3

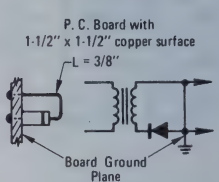
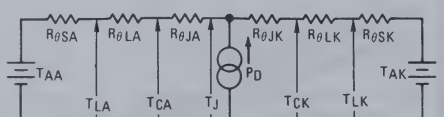


FIGURE 14 – THERMAL CIRCUIT MODEL



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are:

$R_{\theta L}$ = 112°C/W/IN. Typically and 128°C/W/IN Maximum

$R_{\theta J}$ = 18°C/W Typically and 30°C/W Maximum

The maximum lead temperature may be calculated as follows:

$T_L = 150° - \Delta T_{JL}$

ΔT_{JL} can be calculated as shown in NOTE 1 or it may be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \bullet P_F$; P_F may be formulated for sine-wave operation from Figure 3 or from Figure 4 for square-wave operation.

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 – FORWARD RECOVERY TIME

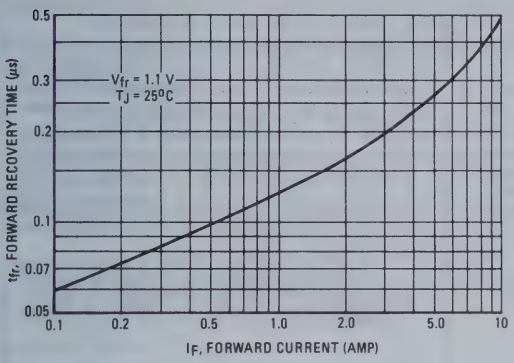
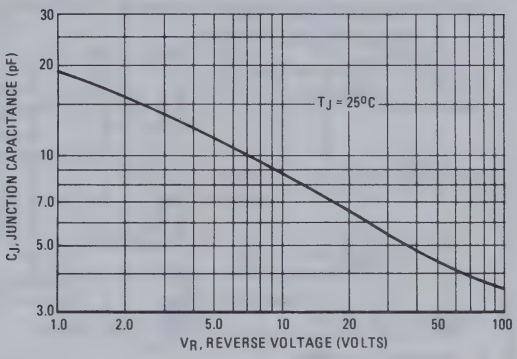


FIGURE 16 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA
(SEE NOTE 3)

FIGURE 17 – T_J = 25°C

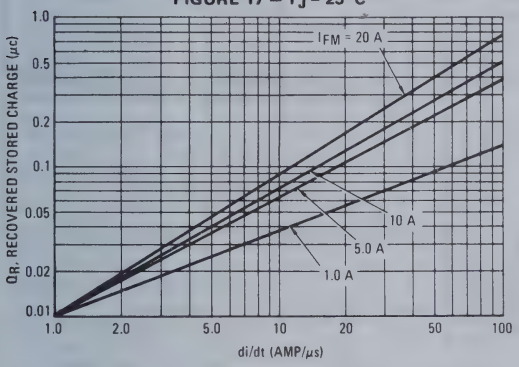


FIGURE 18 – T_J = 75°C

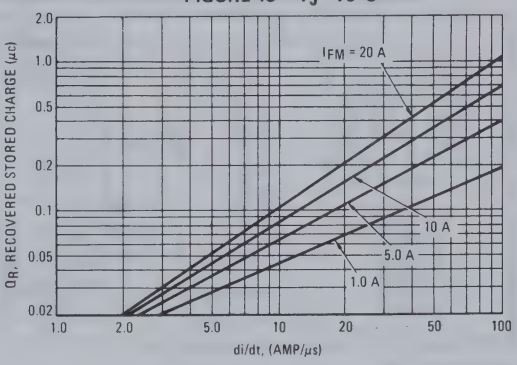


FIGURE 19 – T_J = 100°C

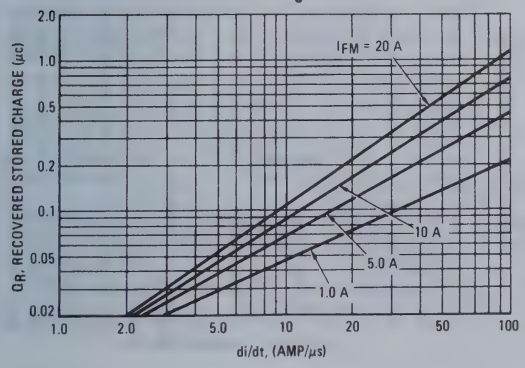


FIGURE 20 – T_J = 150°C

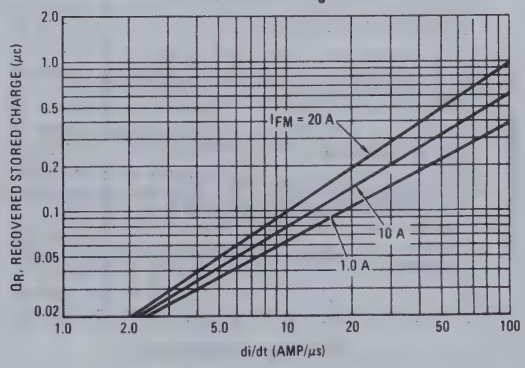


FIGURE 21 – REVERSE RECOVERY CIRCUIT

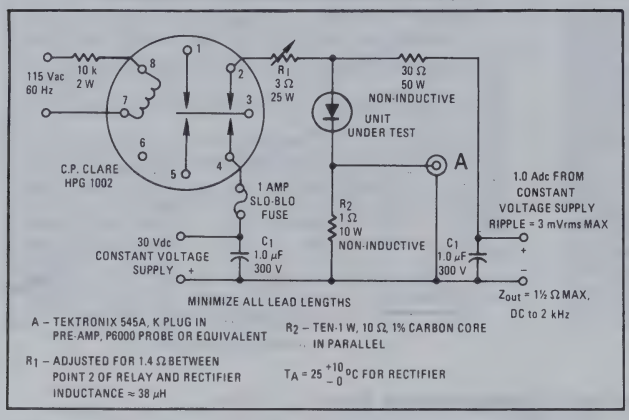
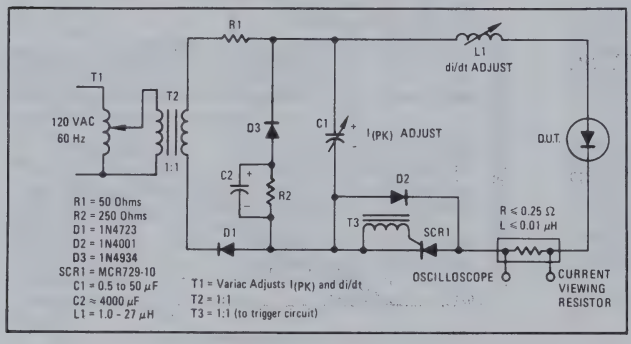


FIGURE 22 – JEDEC REVERSE RECOVERY CIRCUIT



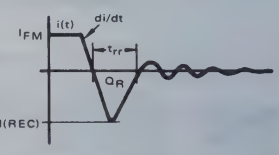
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

FIGURE 23 – TYPICAL REVERSE LEAKAGE

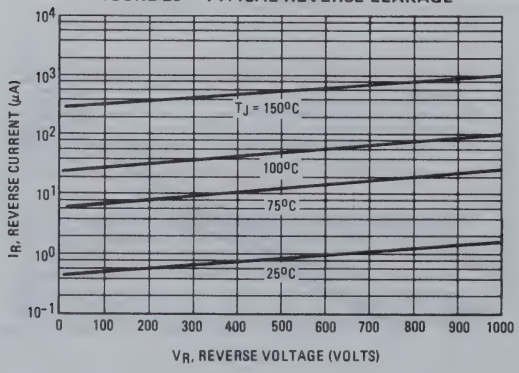
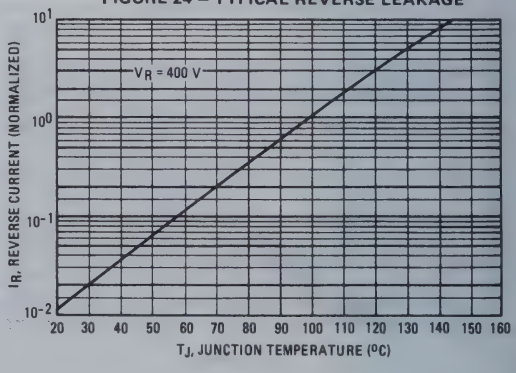


FIGURE 24 – TYPICAL REVERSE LEAKAGE



MR820,MR821,MR822, MR824,MR826

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

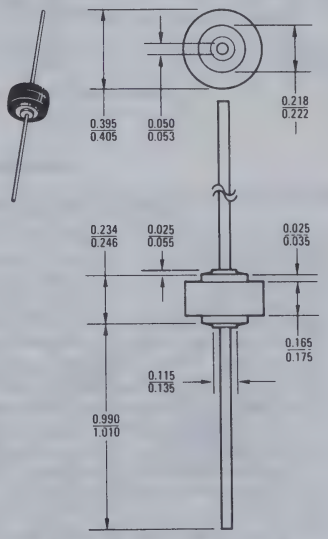
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
5.0 AMPERES



CASE 194

MAXIMUM RATINGS

Rating	Symbol	MR820	MR821	MR822	MR824	MR826	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_A = 55°C) (1)	I_O	← 5.0 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →					Amp
Operating and Storage Junction Temperature Range (2)	T_J,T_{stg}	← −65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 6, Page 8)	$R_{\theta JA}$	25	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 15.7 Amp, T_J = 150°C)	v_F	–	0.75	1.05	Volts
Forward Voltage (I_F = 5.0 Amp, T_J = 25°C)	V_F	–	0.9	1.0	Volts
Maximum Reverse Current, (rated dc voltage) T_J = 25°C	I_R	–	5.0	25	μA
T_J = 100°C MR820		–	–	0.5	mA
T_J = 100°C MR821		–	0.25	0.5	mA
T_J = 100°C MR822		–	–	0.6	mA
T_J = 100°C MR824		–	–	0.8	mA
T_J = 100°C MR826		–	0.4	1.0	mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)	t_{rr}	–	100	200	ns
(I_{FM} = 15 Amp, di/dt = 25 A/μs, Figure 26)		–	150	300	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)	$I_{RM(REC)}$	–	–	2.0	Amp

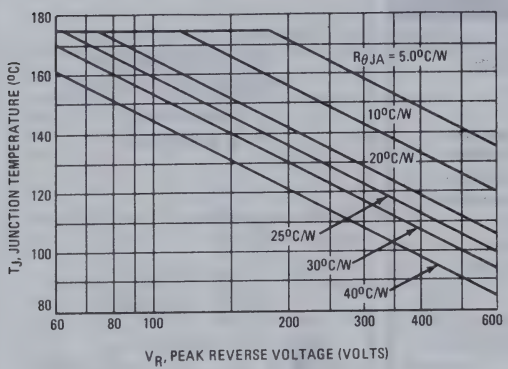
(1) Must be derated for reverse power dissipation. See Note 3
(2) Derate as shown in Figure 1.

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded
FINISH: External Surfaces are Corrosion Resistant
POLARITY: Indicated by Diode Symbol
WEIGHT: 2.5 Grams (Approximately)
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES:
350°C, 3/8" from case for 10 s at 5.0 lb. tension.

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over approximately 85°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 3 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

RESISTIVE LOAD RATINGS

PRINTED CIRCUIT BOARD MOUNTING – SEE NOTE 6, PAGE 8

FIGURE 2 – SINE WAVE INPUT

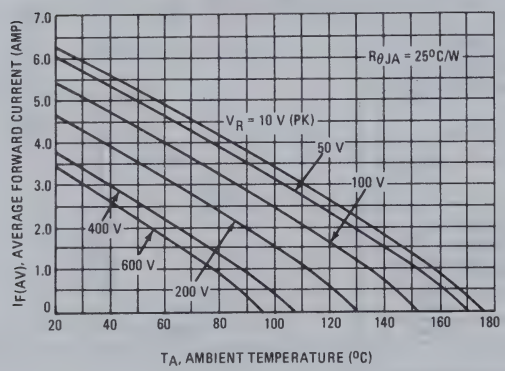


FIGURE 3 – SQUARE WAVE INPUT

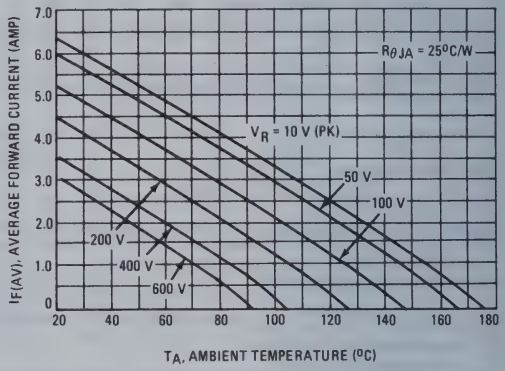


FIGURE 4 – SINE WAVE INPUT

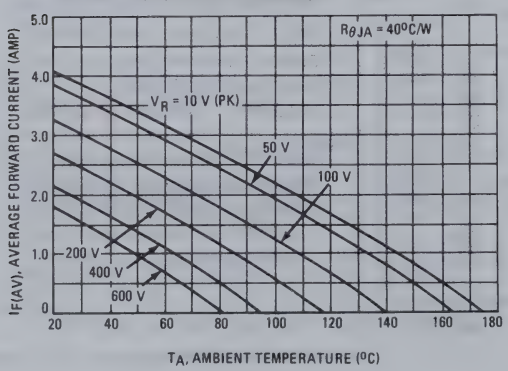
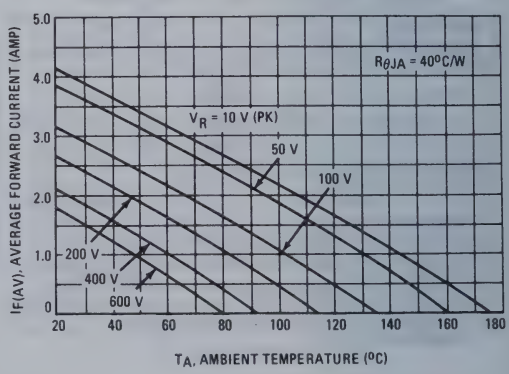


FIGURE 5 – SQUARE WAVE INPUT



MAXIMUM CURRENT RATINGS

NOTE 2

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 3.

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

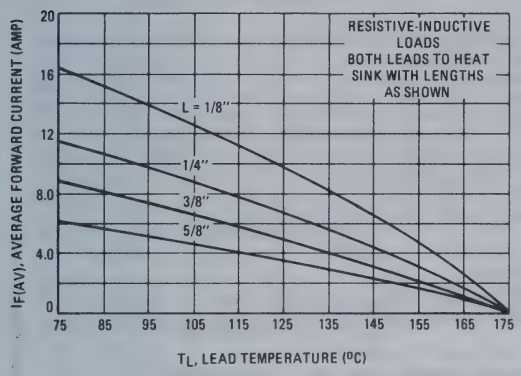


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

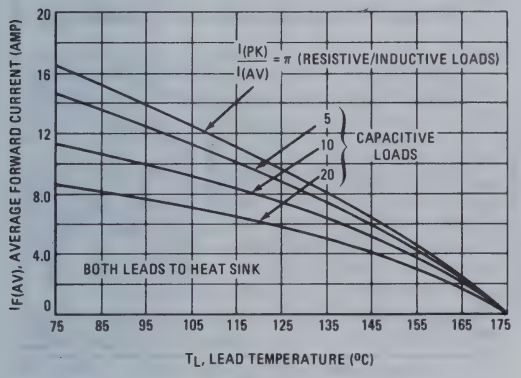
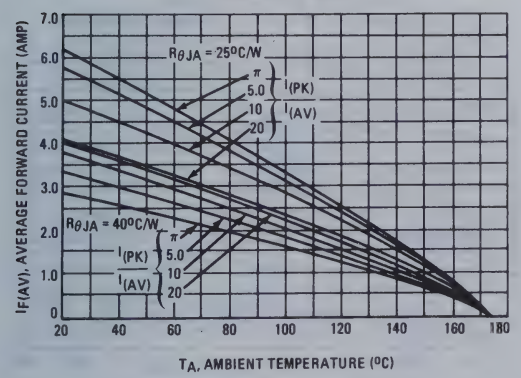


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

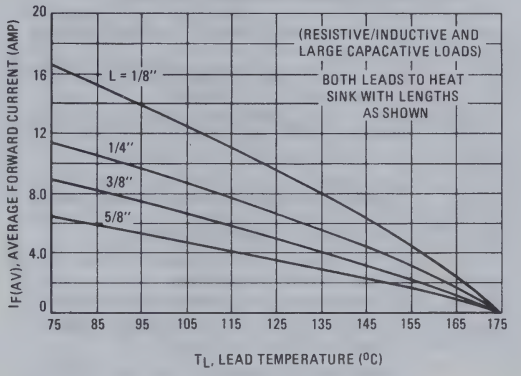


FIGURE 9 – 1/8" LEAD LENGTH, VARIOUS LOADS

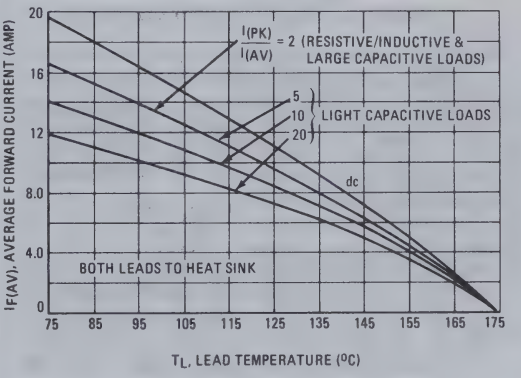
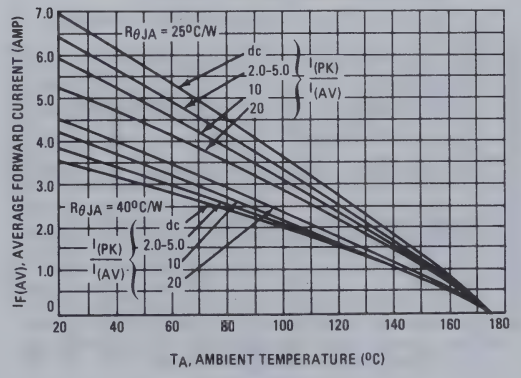


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



REVERSE POWER DISSIPATION AND CURRENT

NOTE 3
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for $T_J = 150°C$. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when V_P is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, V_P is the voltage across one leg of the transformer.

EXAMPLE:

Find Maximum Ambient Temperature for I_{AV} = 2 A, Capacitive Load of I_{PK}/I_{AV} = 20, Input Voltage = 120 V (rms) Sine Wave, $R_{\theta JA}$ = 25°C/W, Half Wave Circuit.

Solution 1:

Step 1: Find V_P; $V_P = \sqrt{2}\ V_{in}$ = 169 V, $V_{R(pk)}$ = 338 V
Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)}$ = 119°C.
Step 3: Find $P_{R(max)}$ from Figure 12. Read P_R = 770 mW @ 140°C
Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)}$ = 0.4
Step 5: Correct P_R to $T_{J(max)}$: $P_R = I_{R(norm)} \times P_R$ (Figure 12)
$P_R = 0.4 \times 770 = 310$ mW.
Step 6: Find P_F from Figure 19. Read P_F = 2.4 W.
Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$
$T_A = 119 - (0.31 + 2.4)(25)$
$T_A = 51°C$

Solution 2:

Steps 1 thru 5 are as above.
Step 6: Find $T_A = T_1$ from Figure 10. Read T_A = 115°C.
Step 7: Compute T_A from $T_A = T_1 - (175 - (T_{J(max)}) - P_R R_{\theta JA}$
$T_A = 115 - (175 - 119) - (0.31)(25)$
$T_A = 51°C$

At times, a discrepancy between methods will occur because thermal response is factored into Solution 2.

FIGURE 12 – SINE WAVE INPUT DISSIPATION

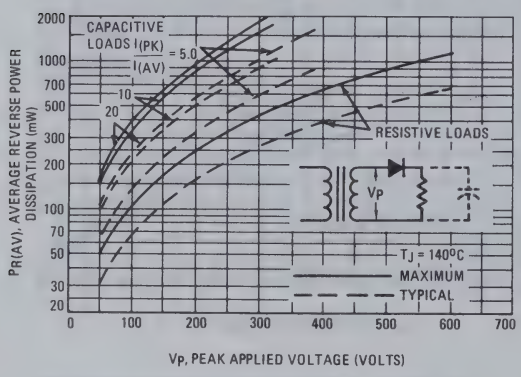


FIGURE 13 – SQUARE WAVE INPUT DISSIPATION

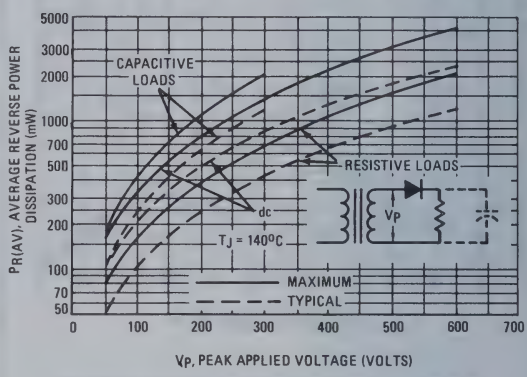


FIGURE 14 – NORMALIZED REVERSE CURRENT

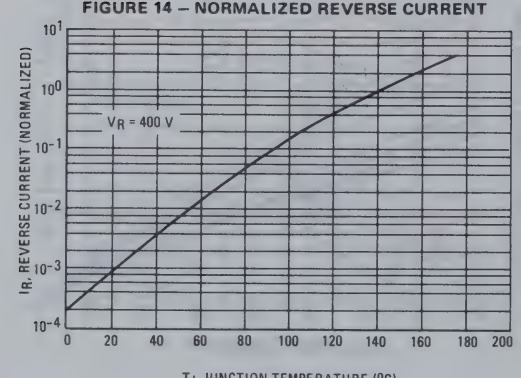
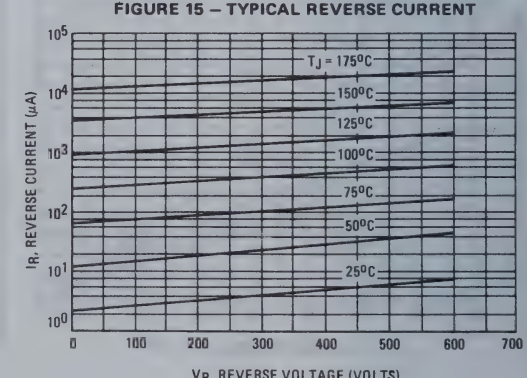


FIGURE 15 – TYPICAL REVERSE CURRENT



STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

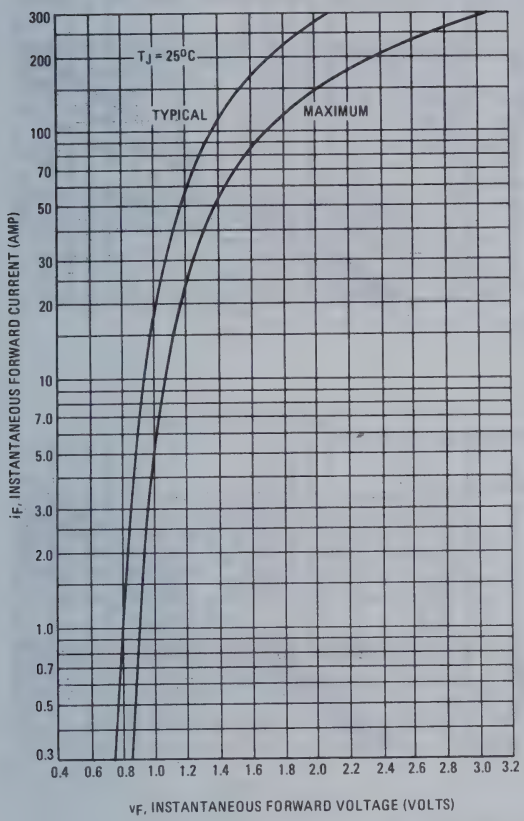


FIGURE 17 – MAXIMUM SURGE CAPABILITY

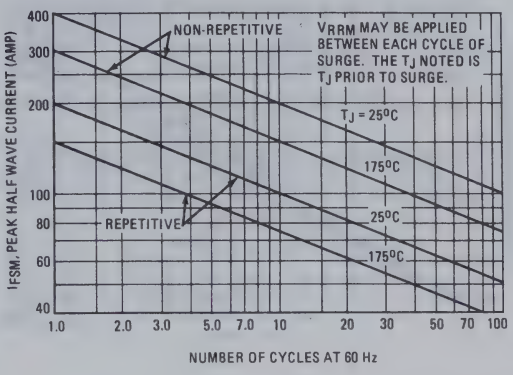
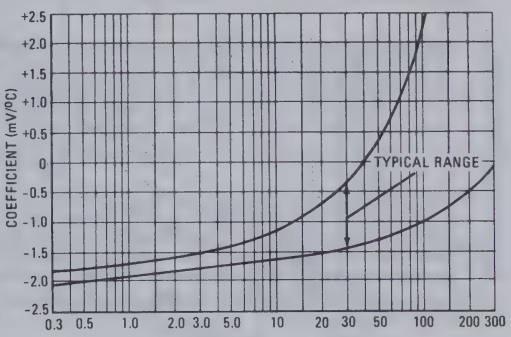


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



MAXIMUM FORWARD POWER DISSIPATION

FIGURE 19 – SINE WAVE INPUT

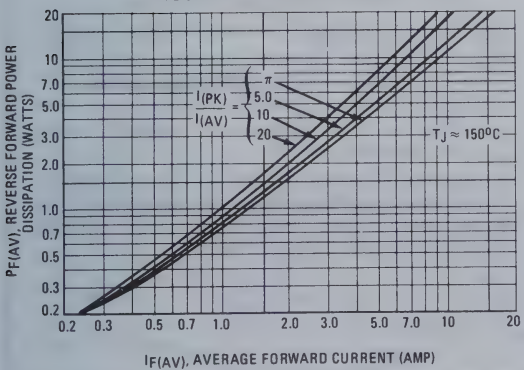
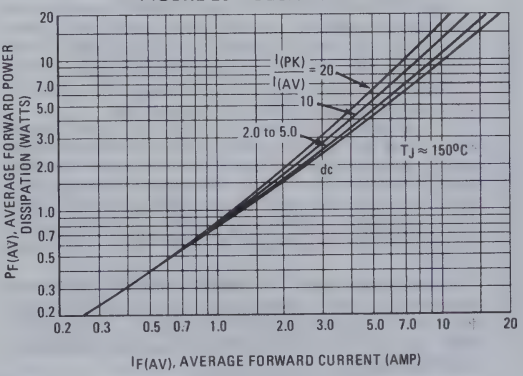


FIGURE 20 – SQUARE WAVE INPUT



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 4)

FIGURE 21 – $T_J = 25^oC$

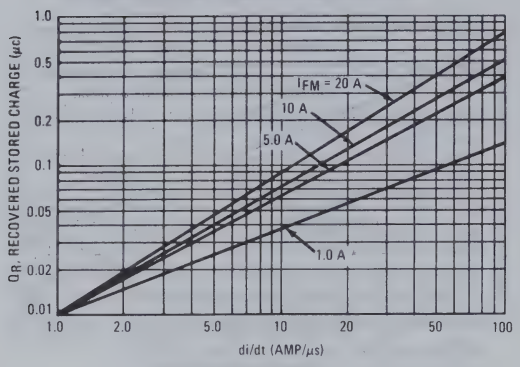


FIGURE 22 – $T_J = 75^oC$

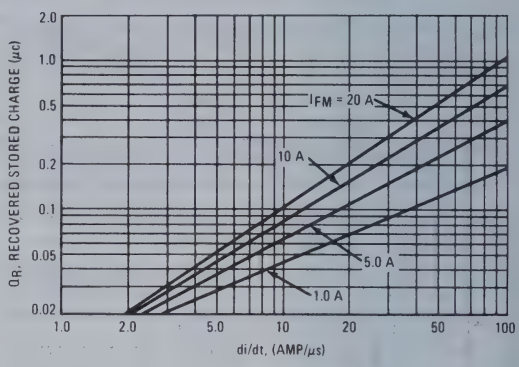


FIGURE 23 – $T_J = 100^oC$

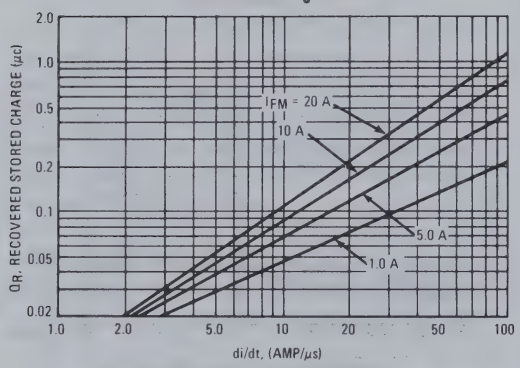
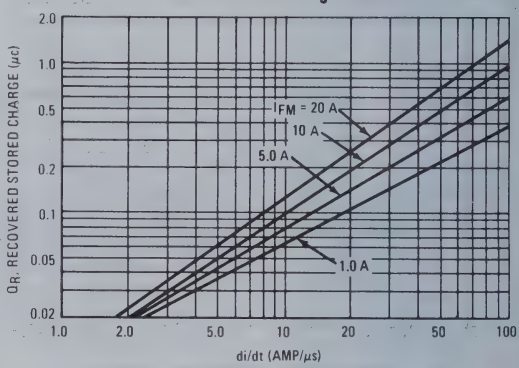


FIGURE 24 – $T_J = 150^oC$



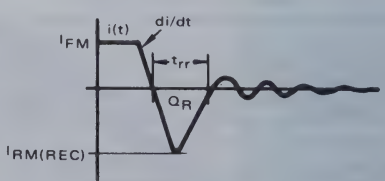
NOTE 4

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using $I_F \simeq 1.0$ A, $V_R = 30$ V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT

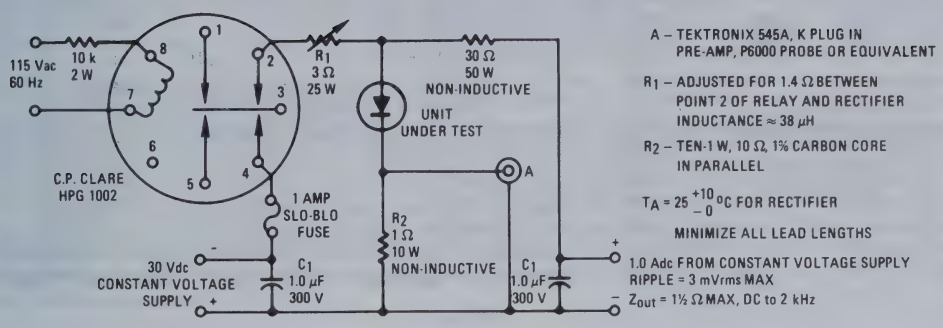


FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT

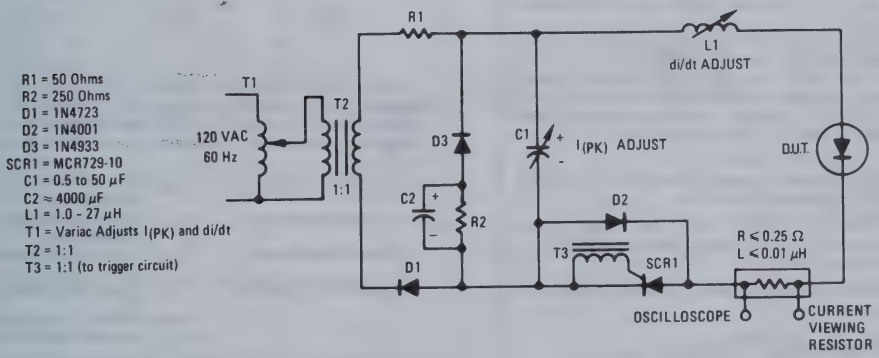


FIGURE 27 – FORWARD RECOVERY TIME

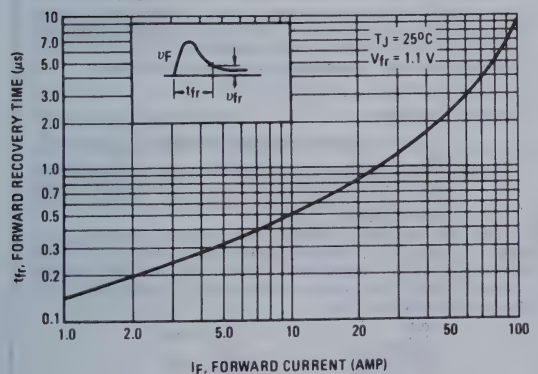
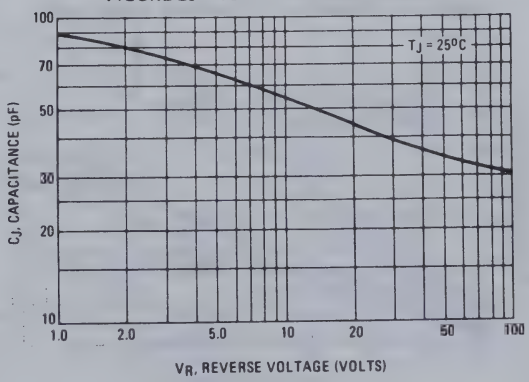
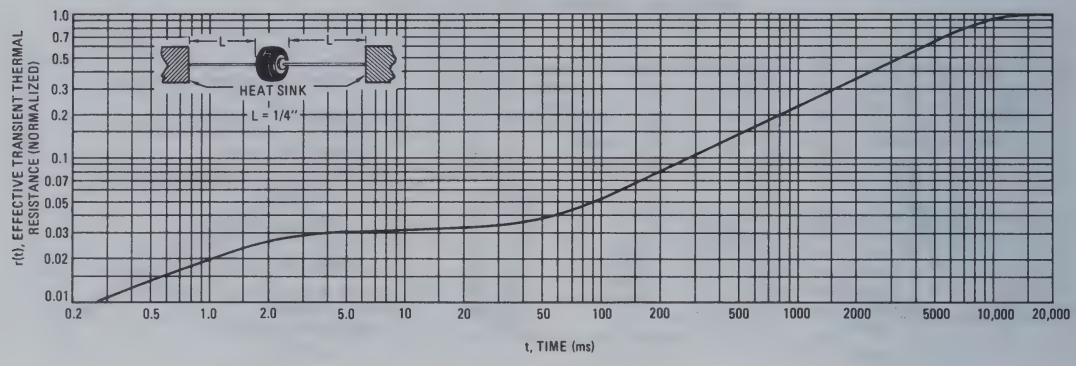


FIGURE 28 – JUNCTION CAPACITANCE



THERMAL CHARACTERISTICS

FIGURE 29 – THERMAL RESPONSE



NOTE 5

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

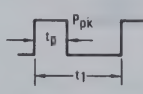
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk} \cdot R_{\theta JL} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

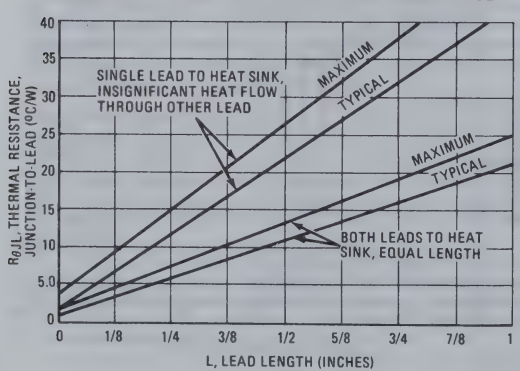
where r(t) = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

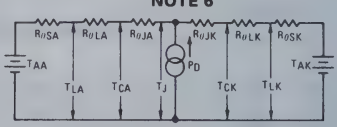


DUTY CYCLE = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 6



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively). Values for thermal resistance components are:

$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum.
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum.

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AV)}$. Therefore maximum lead temperature may be found as follows:

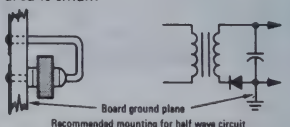
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 12 & 19 for sine wave operation and Figures 13 & 20 for square wave operation.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2" x 1-1/2" copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

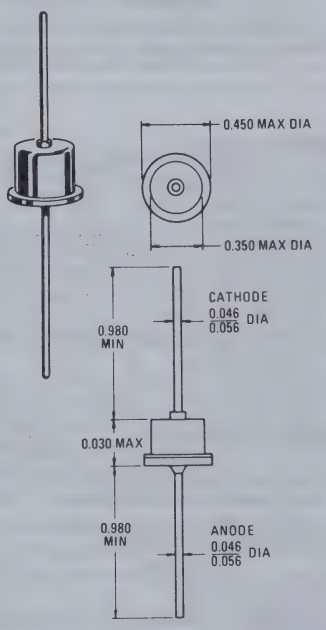
MR830, MR831, MR832
MR834, MR836
MR840, MR841, MR842
MR844, MR846

HERMETICALLY SEALED, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERES



CASE 60

MAXIMUM RATINGS

Rating	Symbol	MR830 MR840	MR831 MR841	MR832 MR842	MR834 MR844	MR836 MR846	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 100°C)	I_O	3.0					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	100					Amps
Operating Junction Temperature Range	T_J	-65 to +150					°C
Storage Temperature Range	T_{stg}	-65 to +175					°C

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Forward Voltage (I_F = 3.0 Adc, T_A = 25°C)	MR830 Series	V_F	–	1.1	Volts
	MR840 Series		–	1.2	
Reverse Current (rated DC Voltage) T_A = 25°C	MR830 Series	I_R	–	0.05	mA
	MR840 Series		–	0.075	
T_A = 100°C	MR830 Series		–	1.5	
	MR840 Series		–	2.5	

REVERSE RECOVERY CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc)	MR830 Series	t_{rr}	–	100	200	ns
	MR840 Series		–	0.5	1.0	μs
(I_{FM} = 15 Amp, di/dt = 25 A/μs)	MR830 Series		–	150	300	ns
	MR840 Series		–	0.75	1.5	μs
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc)		$I_{RM(REC)}$	–	–	2.0	Amp

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and leads readily solderable

POLARITY: Cathode to Case

WEIGHT: 2.4 Grams (Approximately)

MR850,MR851,MR852, MR854,MR856

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

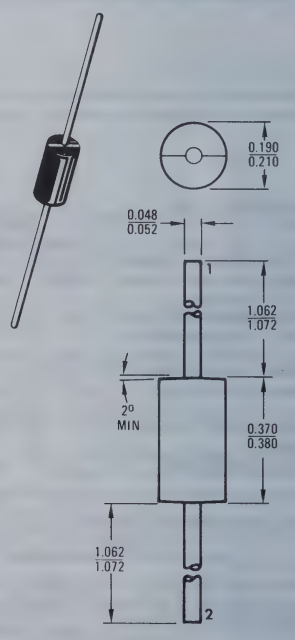
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERE



CASE 267

MAXIMUM RATINGS

Rating	Symbol	MR850	MR851	MR852	MR854	MR856	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase resistive load, T_A = 90°C) (1)	I_O	3.0					Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	100 (one cycle)					Amp
Operating and Storage Junction Temperature Range (2)	T_J,T_{stg}	-65 to +175					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mouting, See Note 6, Page 8)	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 9.4 Amp, T_J = 175°C)		v_F	–	0.9	1.1	Volts
Forward Voltage (I_F = 3.0 Amp, T_J = 25°C)		V_F	–	1.04	1.25	Volts
Reverse Current (rated dc voltage)	T_J = 25°C	I_R	–	2.0	10	μA
	T_J = 100°C MR850		–	–	150	
	T_J = 100°C MR851		–	60	150	
	T_J = 100°C MR852		–	–	200	
	T_J = 100°C MR854		–	–	250	
	T_J = 100°C MR856		–	100	300	

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time	t_{rr}				ns
(I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)		–	100	200	
(I_F = 15 Amp, di/dt = 10 A/μs, Figure 26)		–	150	300	
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)	$I_{RM(REC)}$	–	–	2.0	Amp

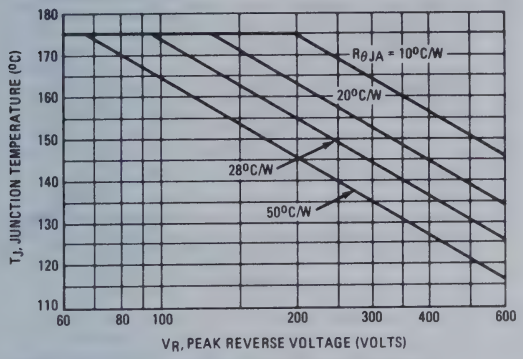
(1) Must be derated for reverse power dissipation. See Note 2, Page 3.
(2) Derate as shown in Figure 1

MECHANICAL CHARACTERISTICS

Case: Void Free, Transfer Molded
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Cathode Indicated by Polarity Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over 120°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 2 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

RESISTIVE LOAD RATINGS

Printed Circuit Board Mounting – See Note 6, Page 8

FIGURE 2 – SINE WAVE INPUT

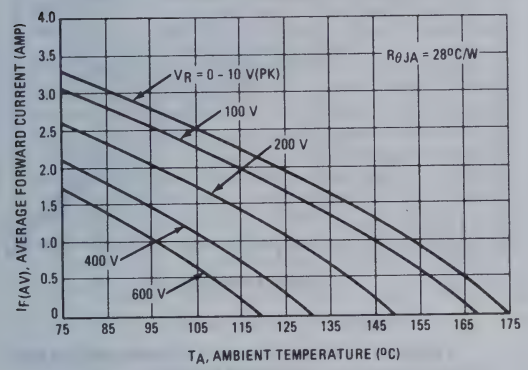


FIGURE 3 – SQUARE WAVE INPUT

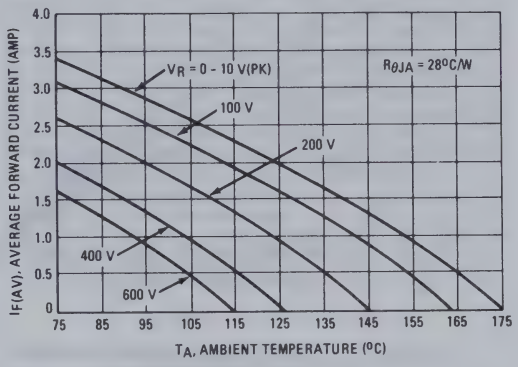


FIGURE 4 – SINE WAVE INPUT

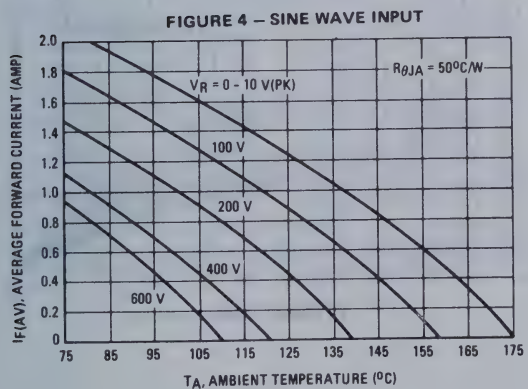
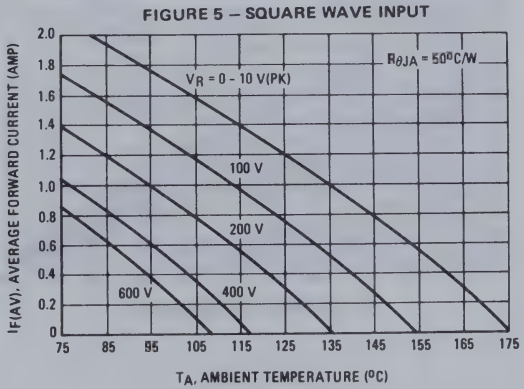


FIGURE 5 – SQUARE WAVE INPUT



MAXIMUM CURRENT RATINGS

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 2.

SINE WAVE INPUTS

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

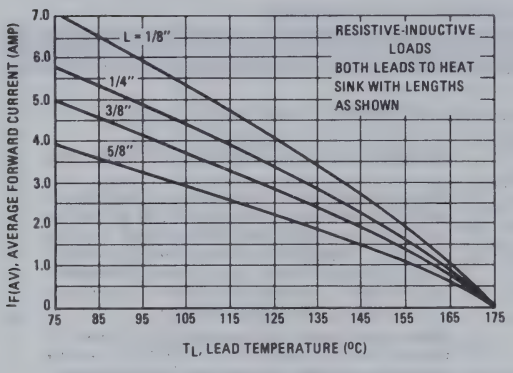


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

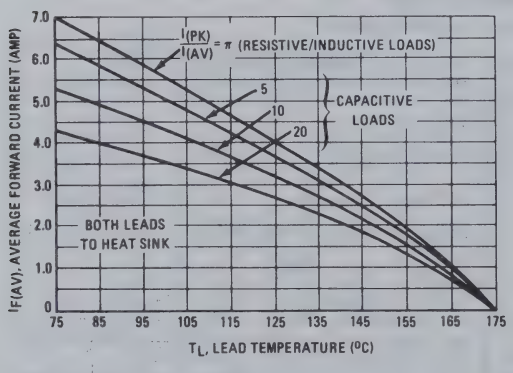
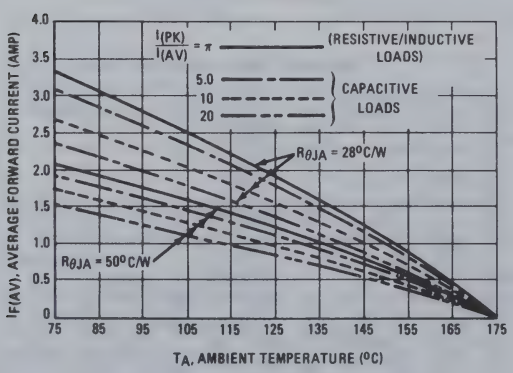


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUTS

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

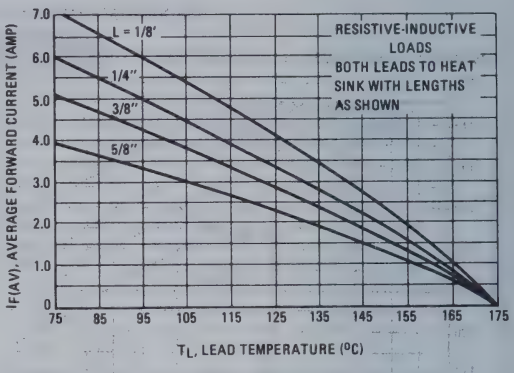


FIGURE 9 – 1/8" LEAD LENGTH, VARIOUS LOADS

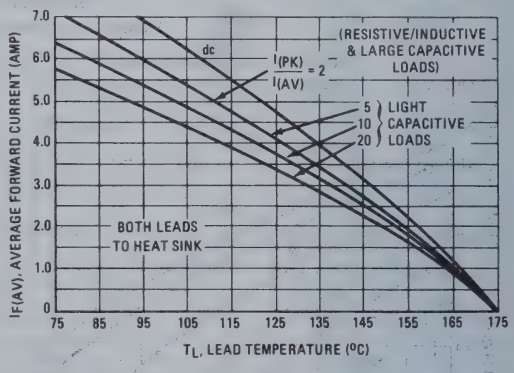
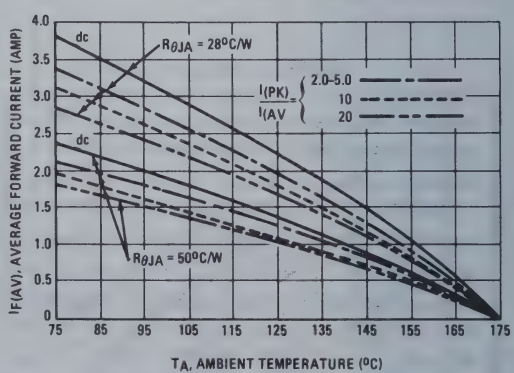


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



REVERSE POWER DISSIPATION AND CURRENT

NOTE 2
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for $T_J = 150°C$. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when V_P is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, V_P is the voltage across one leg of the transformer.

Example 1 Find maximum ambient temperature for I_{AV} = 2 A, capacitive load of I_{PK}/I_{AV} = 20, Input Voltage = 60 V (rms), sine wave, $R_{\theta JA}$ = 28°C/W, half wave circuit.

Solution 1 (using Equation 1)

Step 1: Find V_P; $V_P = \sqrt{2}\, V_{in} = 85$ V, $V_{R(pk)} = 170$

Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)}$ = 157°C

Step 3: Find $P_{R(max)}$ from Figure 12. Read P_R = 360 mW @ 150°C

Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)}$ = 1.5

Step 5: Correct P_R to $T_{J(max)}$. $P_R = I_{R(norm)} \times P_R$ (Figure 12) $P_R = 1.5 \times 360 = 540$ mW

Step 6: Find $T_A = T_1$ from Figure 10. Read T_1 = 94°C

Step 7: Compute T_A from $T_A = T_1 - (175 - T_{J(max)} - P_R R_{\theta JA}$
$T_A = 94 - (175 - 157) - (0.54)(28)$
$T_A = 61°C$

Solution 2 (using Equation 2)

Steps 1 thru 5 are as Solution 1

Step 6: Find P_F from Figure 19. Read P_F = 3.0 W

Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$
$T_A = 157 - (0.54 + 3)28$
$T_A = 58°C$

The discrepancy occurs because thermal response is factored into solution 1, and advantage is taken of the cooling time after the power pulse and before reverse voltage achieves its maximum. 61°C is a satisfactory ambient temperature.

FIGURE 12 – REVERSE POWER DISSIPATION, SINE WAVE

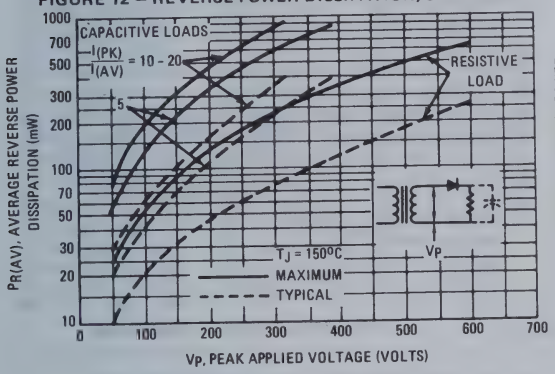


FIGURE 13 – REVERSE POWER DISSIPATION, SQUARE WAVE

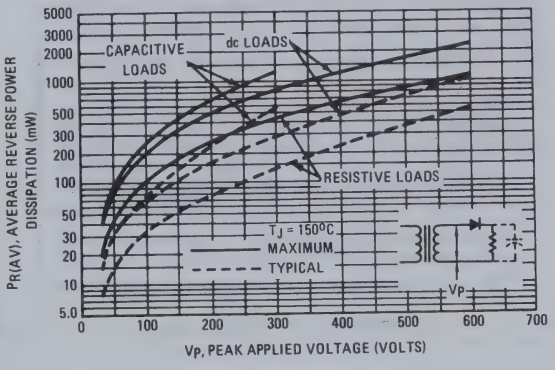


FIGURE 14 – NORMALIZED REVERSE CURRENT

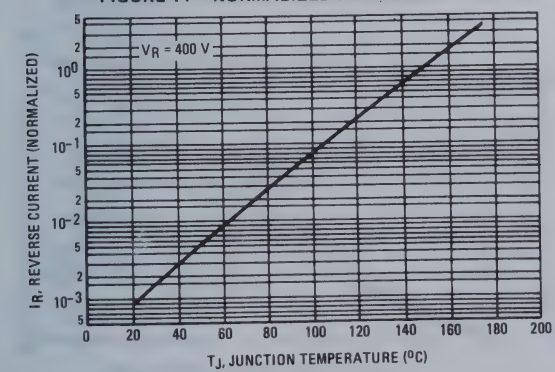
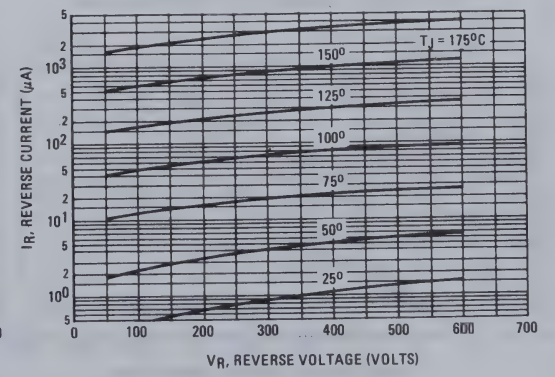


FIGURE 15 – TYPICAL REVERSE CURRENT



STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

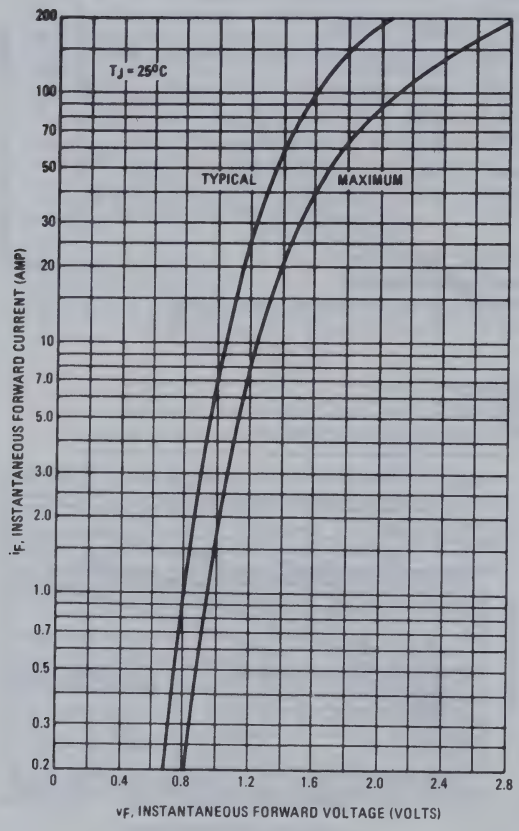


FIGURE 17 – MAXIMUM SURGE CAPABILITY

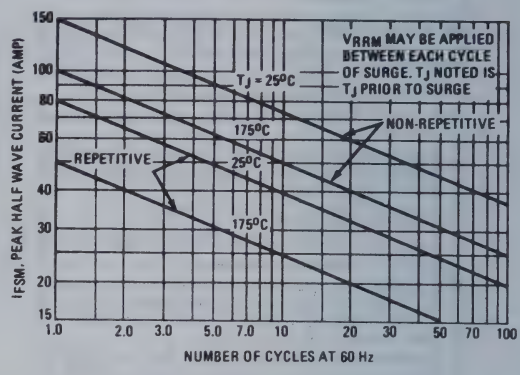
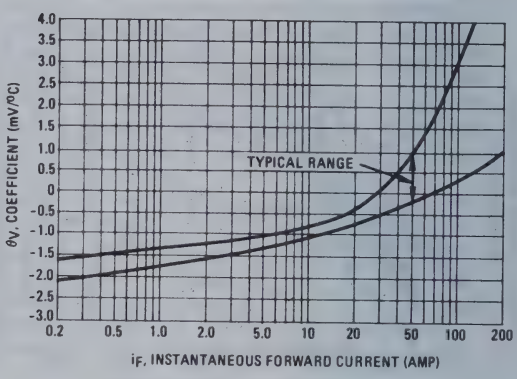
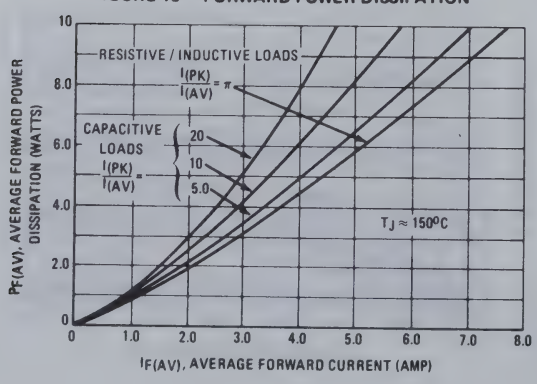


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



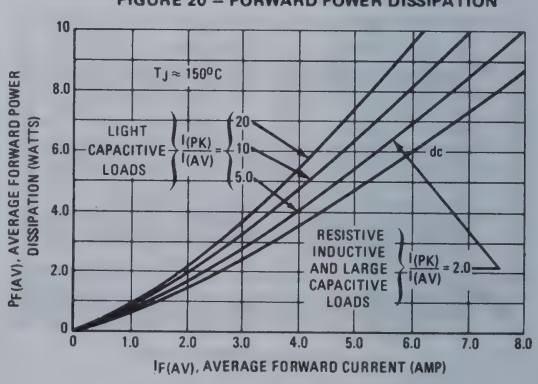
SINE WAVE INPUT

FIGURE 19 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 20 – FORWARD POWER DISSIPATION



TYPICAL RECOVERED STORED CHARAGE DATA

FIGURE 21 – T_J = 25°C (See Note 3)

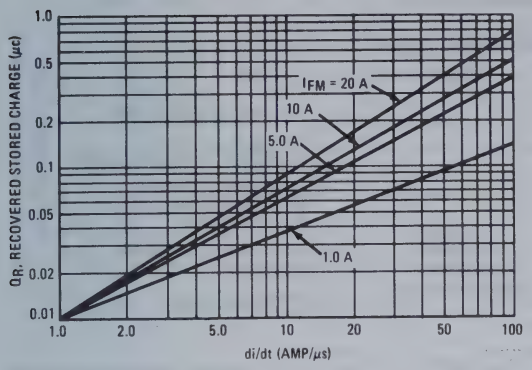


FIGURE 22 – T_J = 75°C

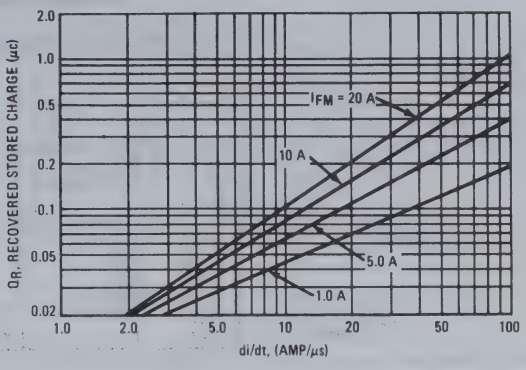


FIGURE 23 – T_J = 100°C

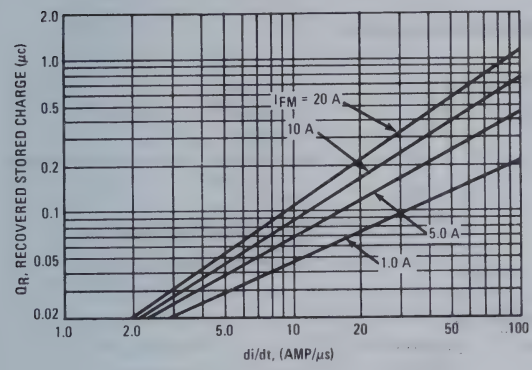
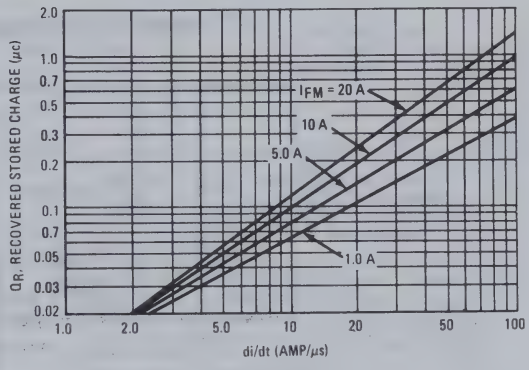


FIGURE 24 – T_J = 150°C



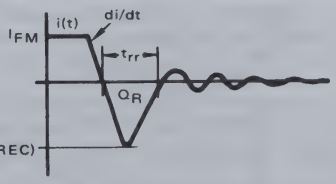
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT

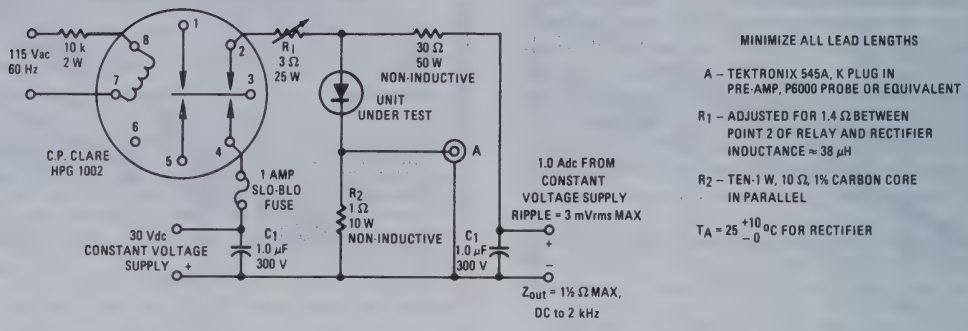


FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT

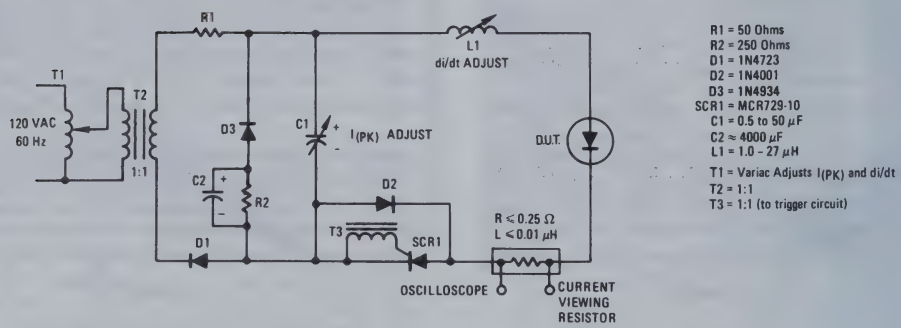


FIGURE 27 – FORWARD RECOVERY TIME

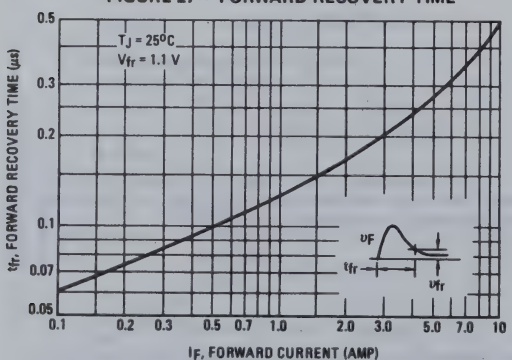


FIGURE 28 – JUNCTION CAPACITANCE

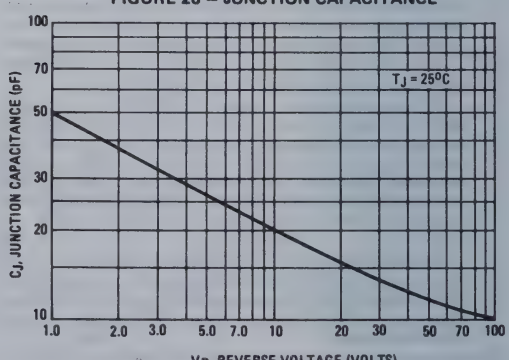


FIGURE 29 – THERMAL RESPONSE

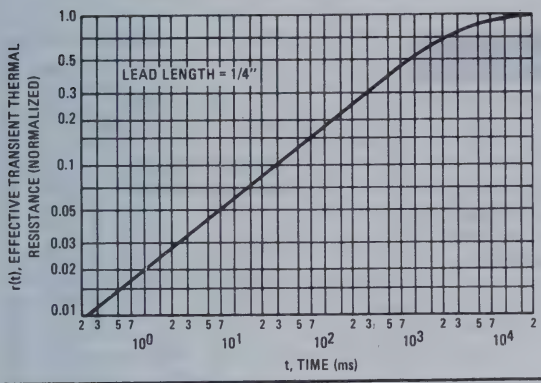
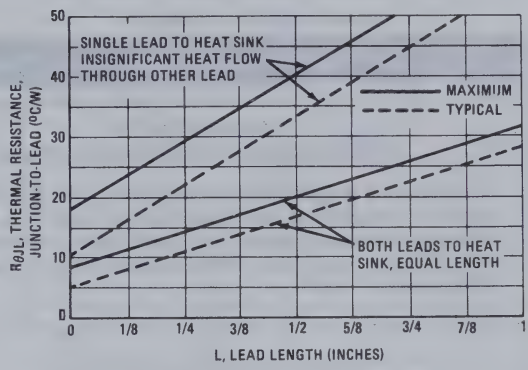


FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 4

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

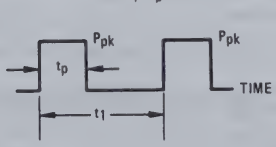
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk} \cdot R_{\theta JL} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where r(t) = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.



DUTY CYCLE = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

NOTE 5

Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature	$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
T_L = Lead Temperature	$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
T_C = Case Temperature	$R_{\theta J}$ = Thermal Resistance, Junction to Case
T_J = Junction Temperature	P_D = Total Power Dissipation = $P_F + P_R$
	P_F = Forward Power Dissipation
	P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.) Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

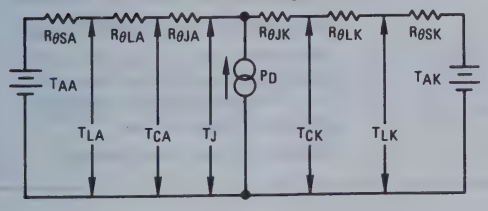
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 2 and 4 for sine wave operation and Figures 3 and 5 for square wave operation.

THERMAL CIRCUIT MODEL
(For Heat Conduction Through the Leads)



NOTE 6

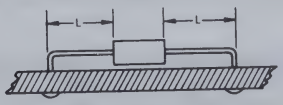
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

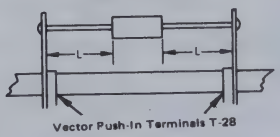
MOUNTING METHOD	LEAD LENGTH, L (IN) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.

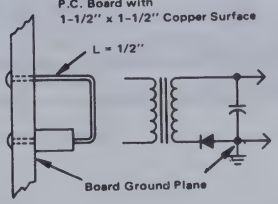


MOUNTING METHOD 2
Vector Pin Mounting



MOUNTING METHOD 3

P.C. Board with 1-1/2" x 1-1/2" Copper Surface



MR860, MR861, MR862, MR864, MR866

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
40 AMPERES



MAXIMUM RATINGS

Rating	Symbol	MR860	MR861	MR862	MR864	MR866	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 100°C)	I_O	40					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	350					Amps
Operating Junction Temperature Range	T_J	-65 to +160					°C
Storage Temperature Range	T_{stg}	-65 to +175					°C

THERMAL CHARACTERISTICS

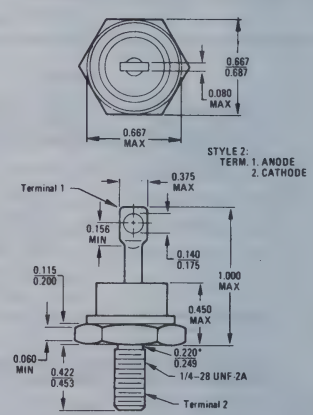
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.85	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 125 Amp, T_J = 150°C)	v_F	–	1.3	1.6	Volts
Forward Voltage (I_F = 40 Amp, T_C = 25°C)	V_F	–	1.0	1.4	Volts
Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	– –	25 1.0	50 2.0	μA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	– –	100 200	200 400	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp



*Dimension is a diameter.

All JEDEC dimensions and notes apply

CASE 257
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case

WEIGHT: 17 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

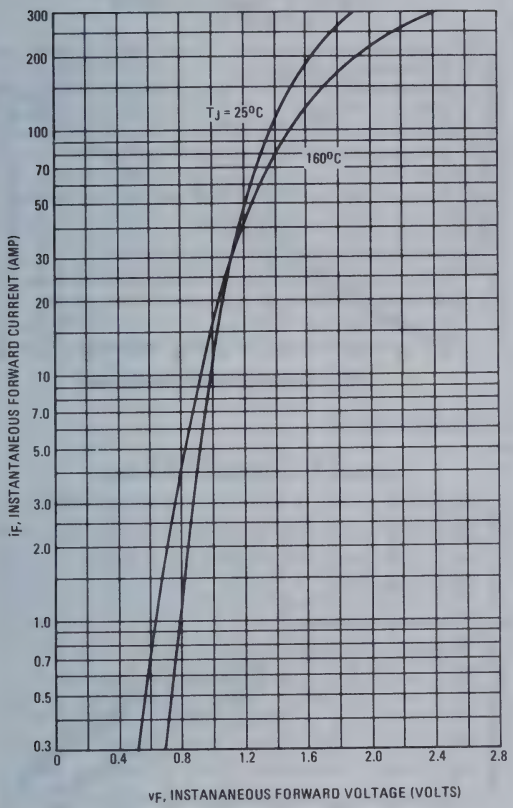
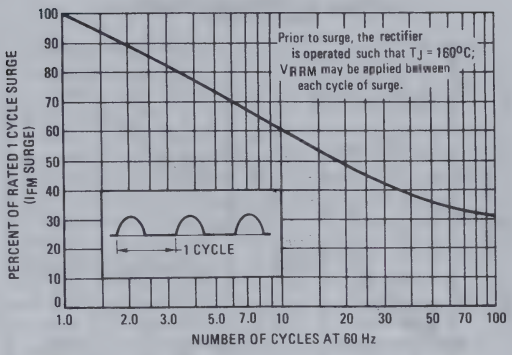
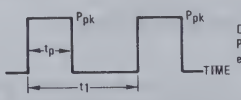


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

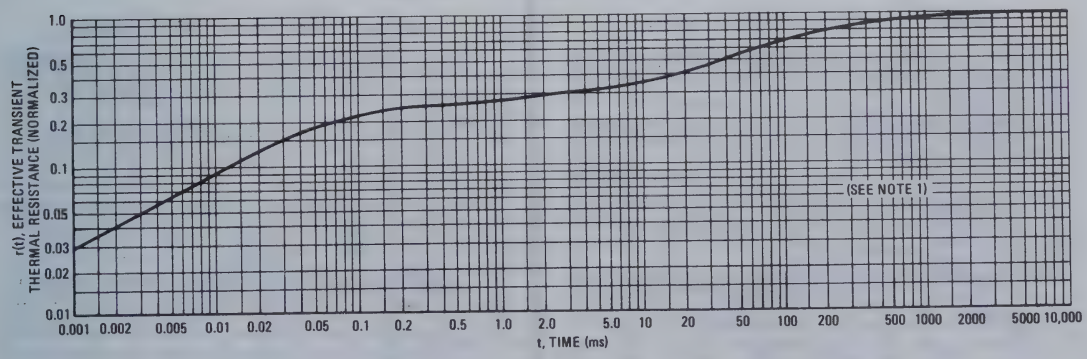
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

r(t) = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION

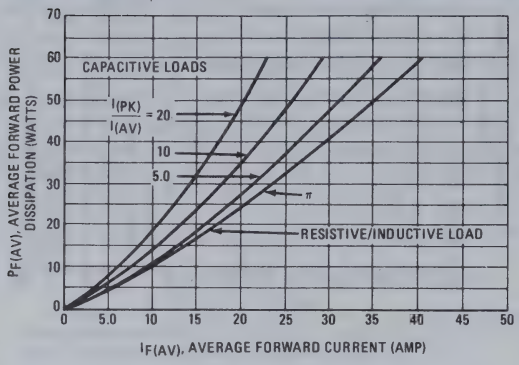


FIGURE 6 – CURRENT DERATING

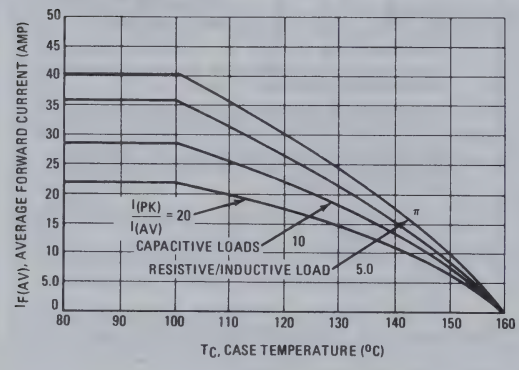
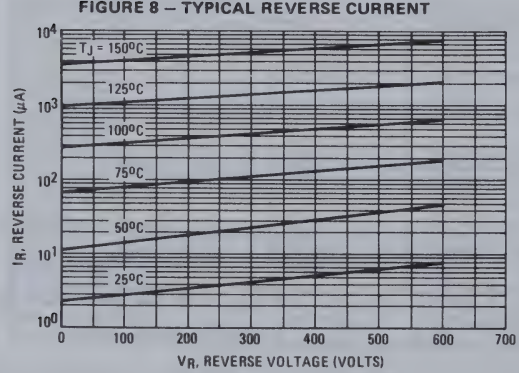


FIGURE 8 – TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

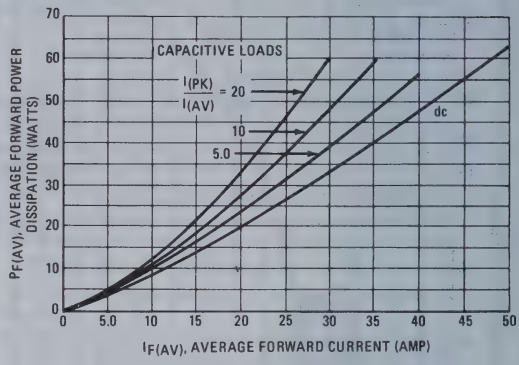


FIGURE 7 – CURRENT DERATING

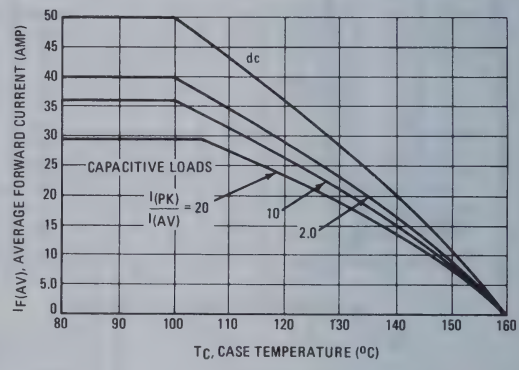


FIGURE 9 – NORMALIZED REVERSE CURRENT

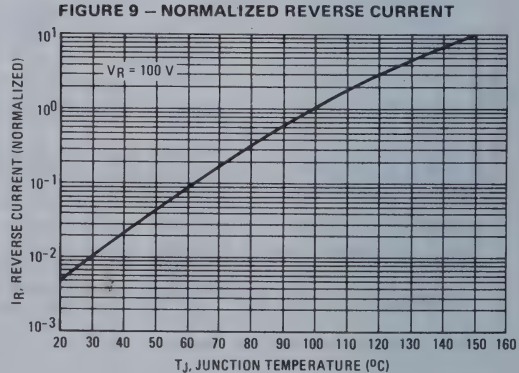


FIGURE 10 – FORWARD RECOVERY TIME

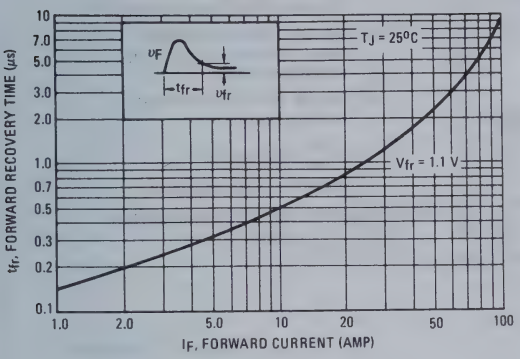
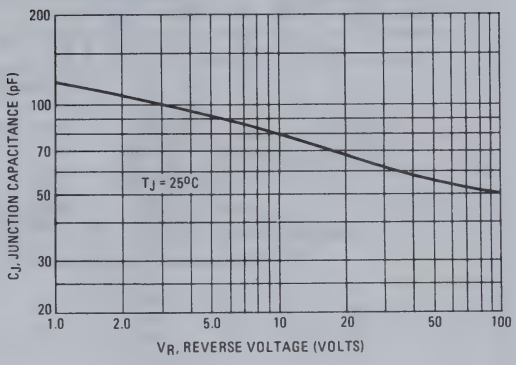


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – T_J = 25°C

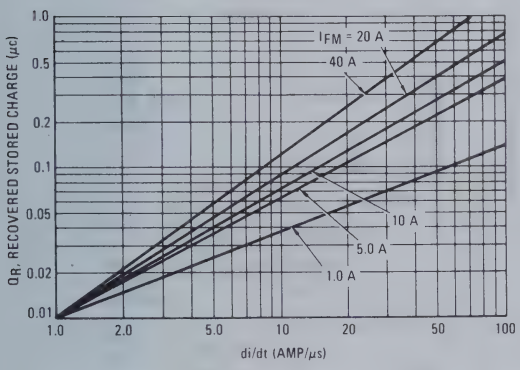


FIGURE 13 – T_J = 75°C

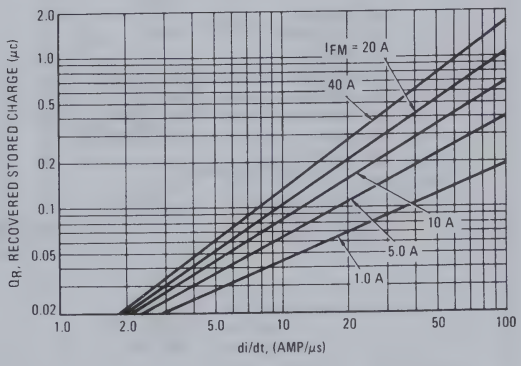


FIGURE 14 – T_J = 100°C

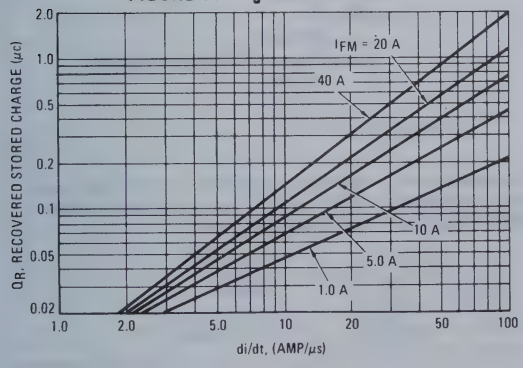


FIGURE 15 – T_J = 150°C

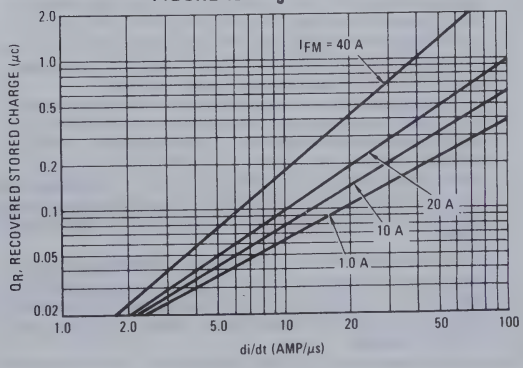


FIGURE 16 – REVERSE RECOVERY CIRCUIT

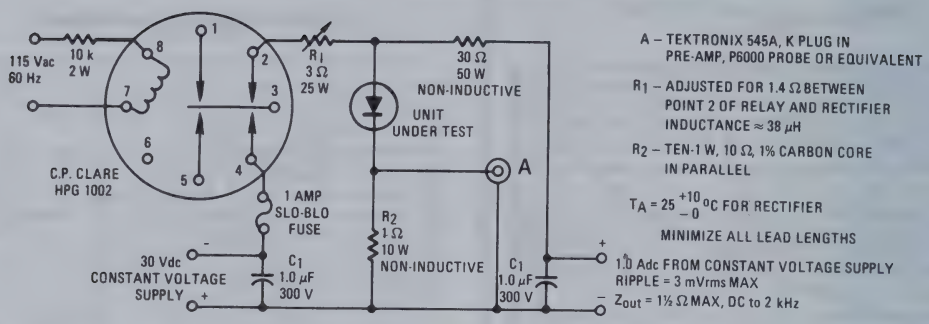
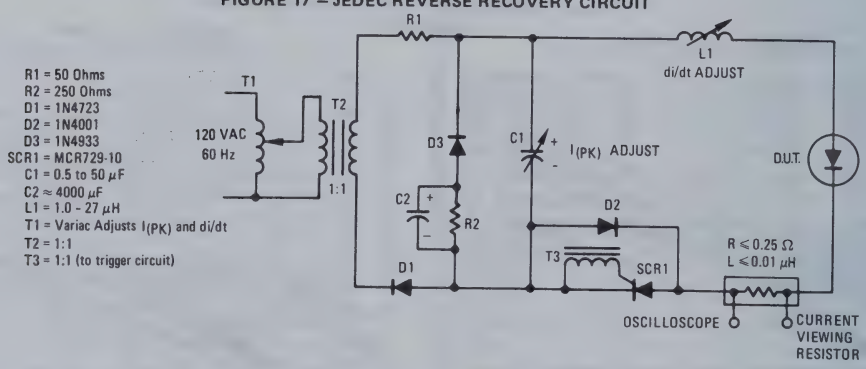


FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT



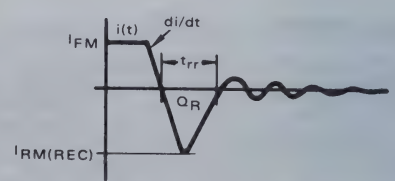
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.

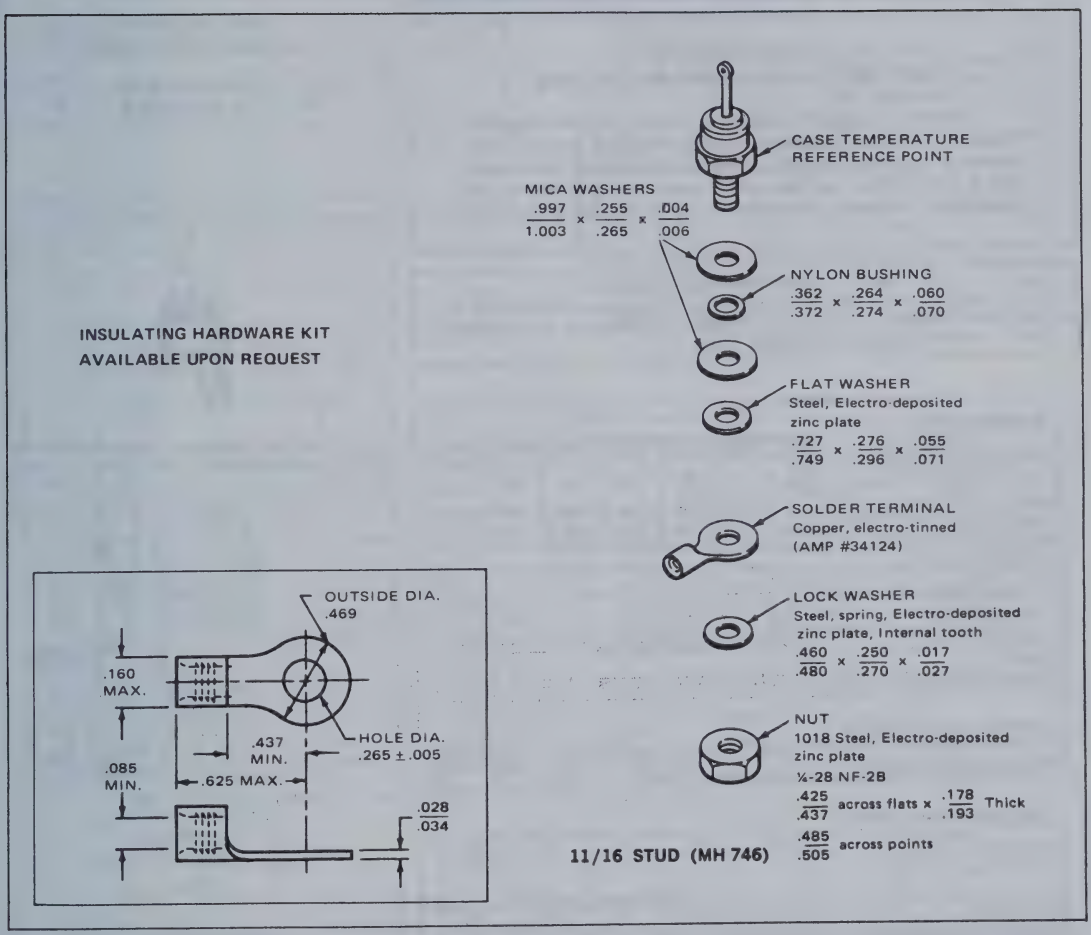


From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

NOTE 3



CASE TO HEAT SINK THERMAL RESISTANCE UNDER VARIOUS CONDITIONS

Metal-to-Metal		Mica Insulation	
Dry	Lubrication	Dry	Lubrication
0.38	0.20	0.89	0.70

TORQUE: 25 IN LBS

MR870, MR871, MR872, MR874, MR876

Designers™ Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR870	MR871	MR872	MR874	MR876	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 100°C)	I_O	← 50 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 400 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →					°C
Storage Temperature Range	T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 157 Amp, T_J = 160°C)	v_F	–	1.3	1.6	Volts
Forward Voltage (I_F = 50 Amp, T_C = 25°C)	V_F	–	1.1	1.4	Volts
Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	– –	25 1.0	50 2.0	μA mA

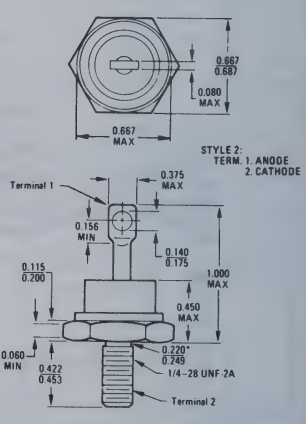
REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	– –	120 240	200 400	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
50 AMPERES





*Dimension is a diameter.

All JEDEC dimensions and notes apply

CASE 257
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistant and readily solderable
POLARITY: Cathode to Case
WEIGHT: 17 grams (approximately)

FIGURE 1 – FORWARD VOLTAGE

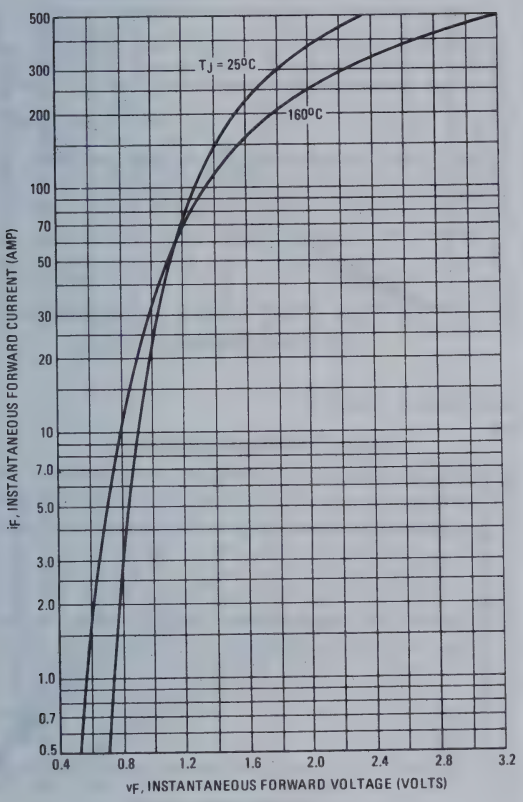
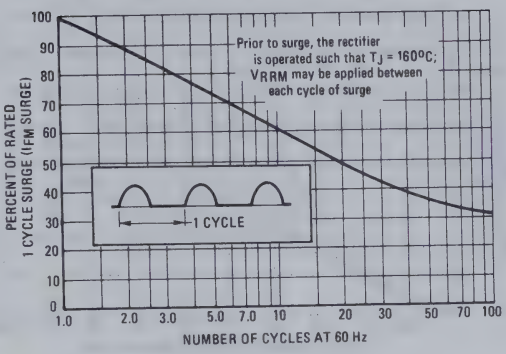
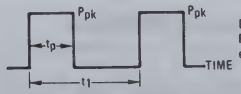


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

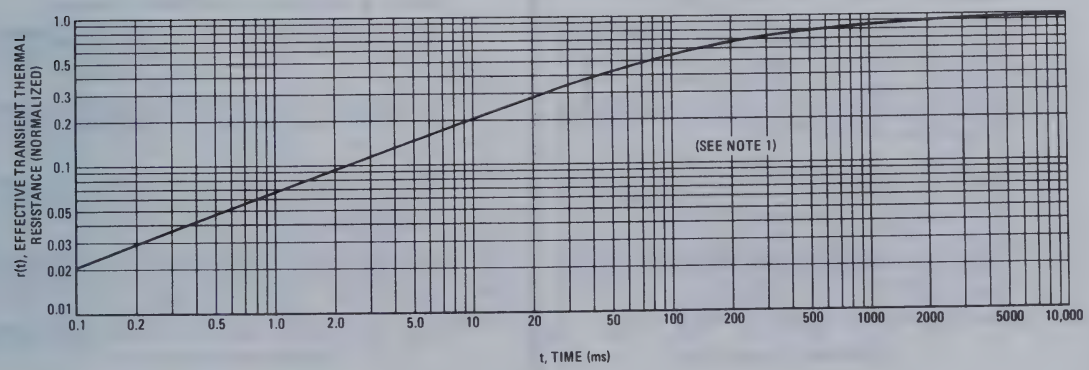
$$\Delta T_{JC} = P_{pk} \cdot R\theta_{JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

r(t) = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.:

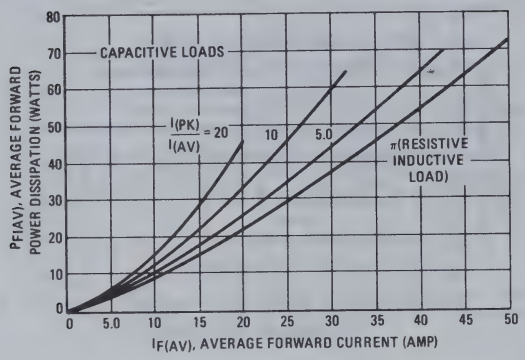
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

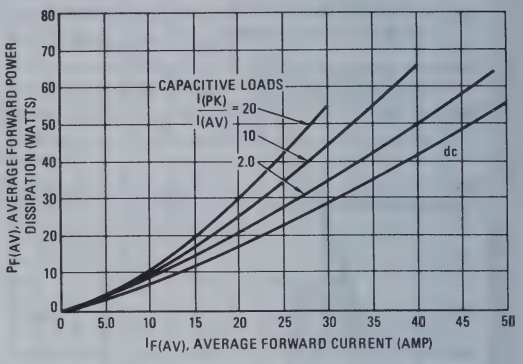


FIGURE 6 – CURRENT DERATING

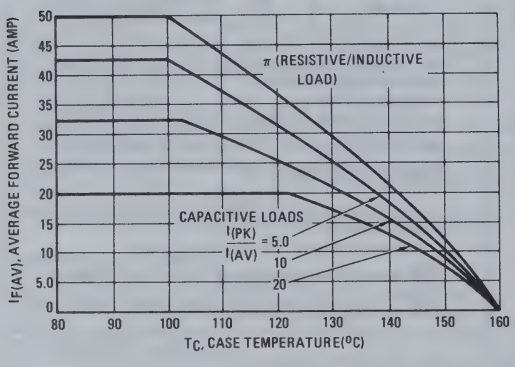


FIGURE 7 – CURRENT DERATING

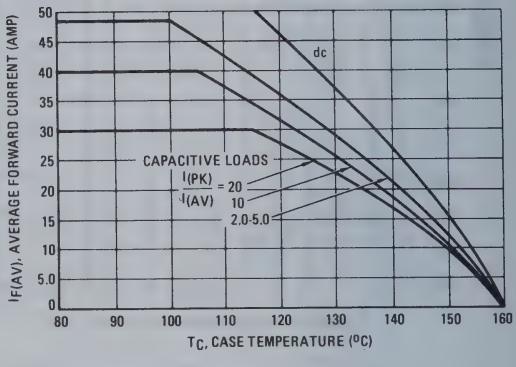


FIGURE 8 – TYPICAL REVERSE CURRENT

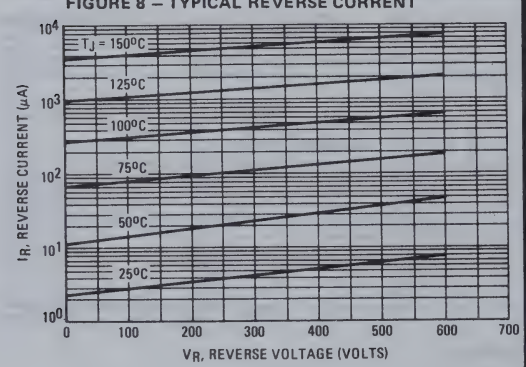
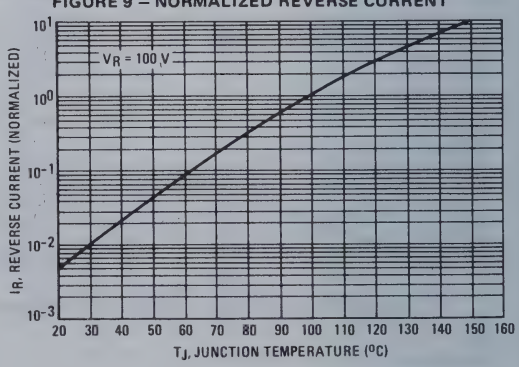


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

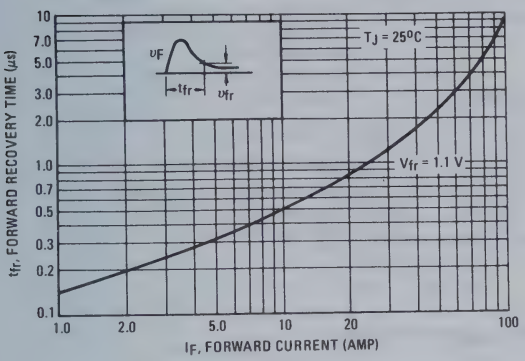
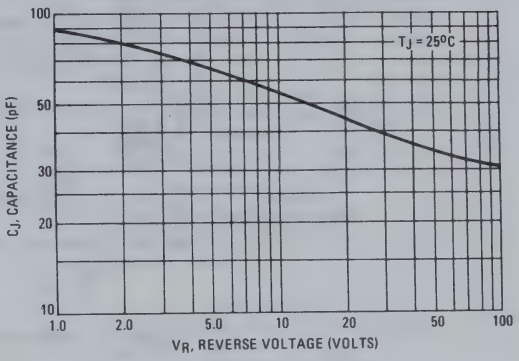


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – T_J = 25°C

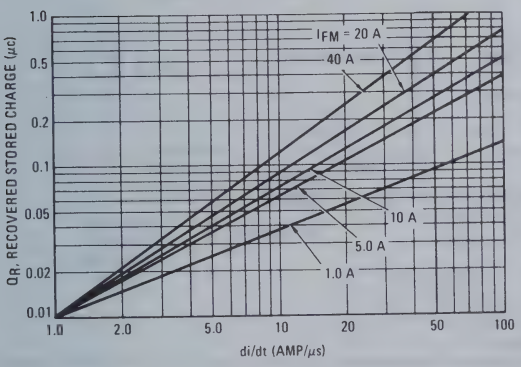


FIGURE 13 – T_J = 75°C

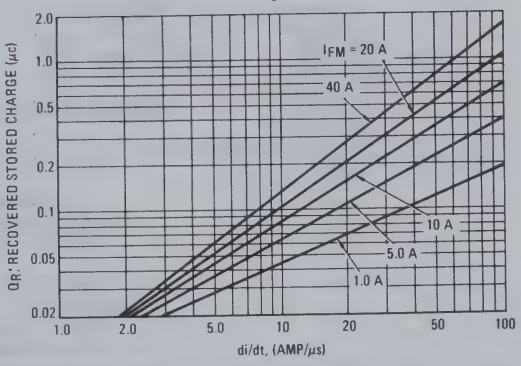


FIGURE 14 – T_J = 100°C

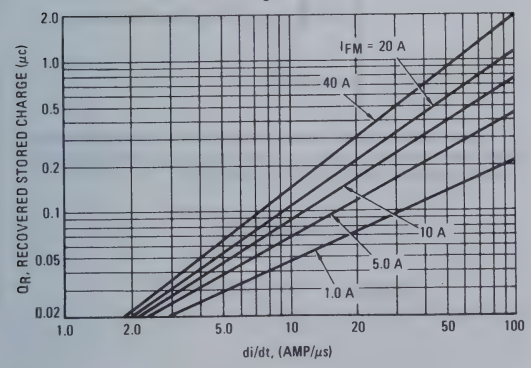


FIGURE 15 – T_J = 150°C

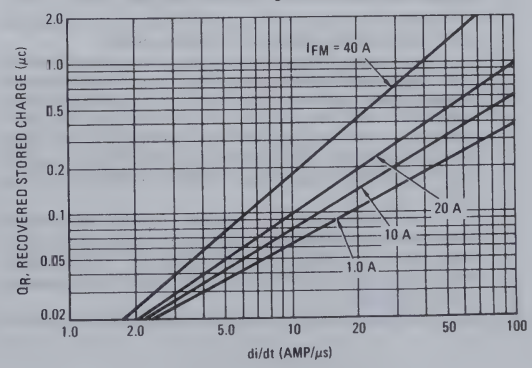


FIGURE 16 – REVERSE RECOVERY CIRCUIT

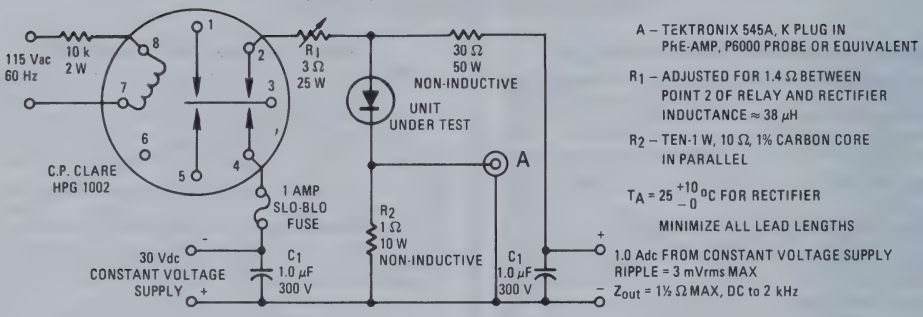
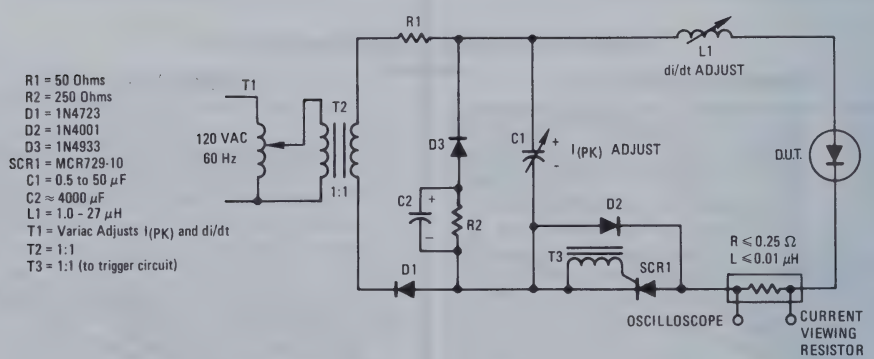


FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT



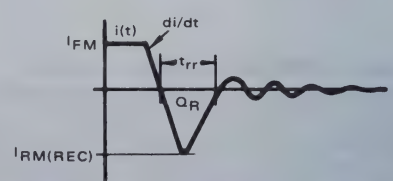
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.

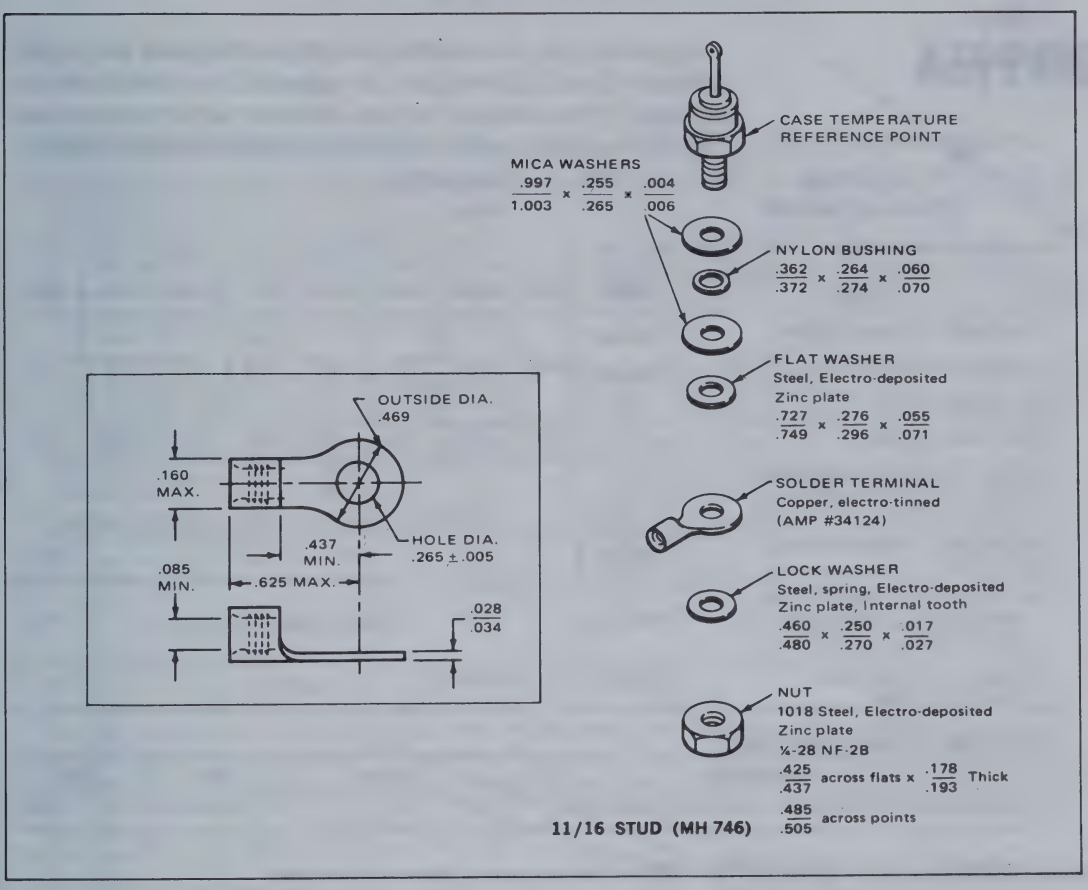


From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

INSULATING HARDWARE KIT AVAILABLE UPON REQUEST

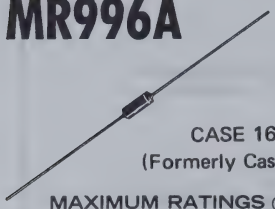


CASE TO HEAT SINK THERMAL RESISTANCE UNDER VARIOUS CONDITIONS

Metal-to-Metal		Mica Insulation	
Dry	Lubrication	Dry	Lubrication
0.38	0.20	0.89	0.70

TORQUE: 25 IN LBS

MR990A (SILICON) thru MR996A



CASE 169
(Formerly Case 59A)

High-voltage, low-current rectifiers designed for applications where high-voltages in subminiature packages are required. These devices feature efficient high-temperature current-handling performance, high surge-current capabilities and surface passivation.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MR990A	MR991A	MR992A	MR993A	MR994A	MR995A	MR996A	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	1000	1500	2000	2500	3000	4000	5000	Volts
RMS Reverse Voltage	V_r	700	1050	1400	1750	2100	2800	3500	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_A = 75°C)	I_O	250							mA
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	2.0							Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	$I_{FM(surge)}$	15 (for 1/2 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150							°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1 inch lead length)	θ_{JA}	100	°C/W

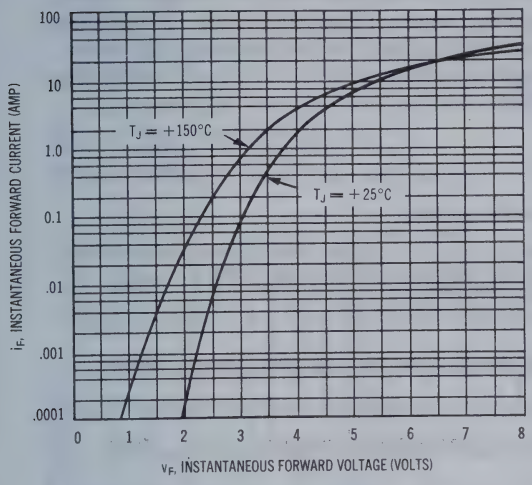
ELECTRICAL CHARACTERISTICS (At 60 Hz Sinusoidal, Resistive or Inductive)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	1.7	Volts
DC Forward Voltage Drop (I_F = 0.25 Adc, T_A = 25°C)	V_F	3.5	Volts
Full Cycle Average Reverse Current (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	100	μA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	10	μA

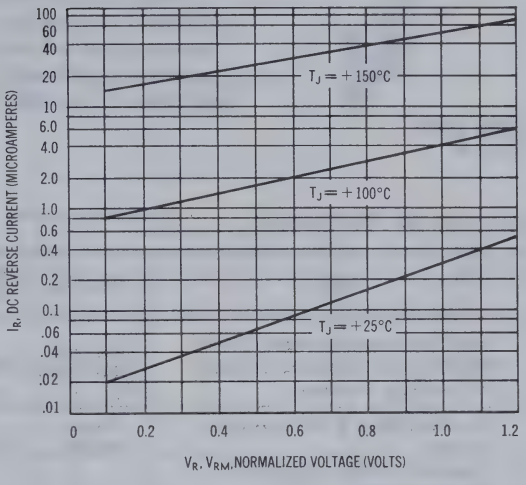
MECHANICAL CHARACTERISTICS

CASE: Void free, flame-proof silicone polymer case
FINISH: All external surfaces corrosion-resistant and leads readily solderable
POLARITY: Indicated by polarity band
MOUNTING POSITIONS: Any
WEIGHT: 0.40 Gram (approx)
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds

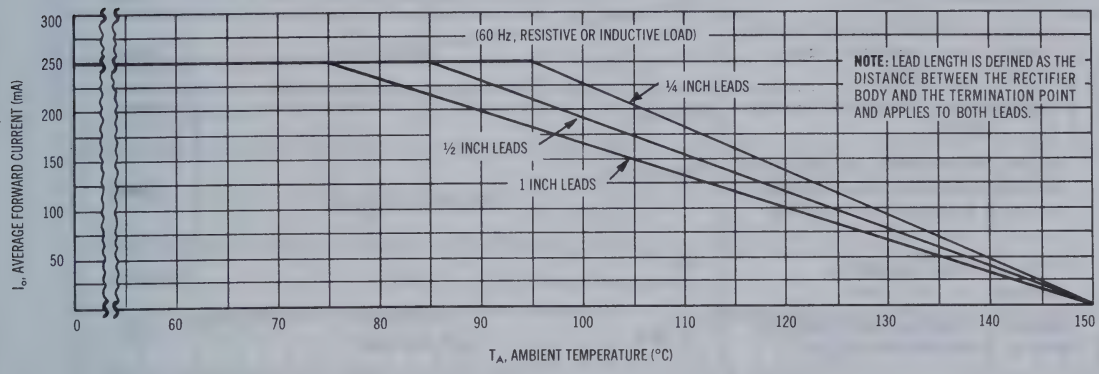
TYPICAL FORWARD CHARACTERISTICS



TYPICAL REVERSE CHARACTERISTICS



CURRENT DERATING



MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT



MR1030 thru MR1036
MR1038, MR1040

For Specifications, See 1N4719 Data, Volume 1.

MR1120 thru MR1126 (SILICON)
MR1128
MR1130



CASE 56A
(DO-4)

Medium-current silicon rectifiers feature high surge current capacity, and low forward voltage drop. Devices have cathode-to-case polarity, but reverse polarity units may be obtained by adding the suffix "R" to the device number i.e. MR1130R.

MAXIMUM RATINGS

Rating	Symbol	MR 1120	MR 1121	MR 1122	MR 1123	MR 1124	MR 1125	MR 1126	MR 1128	MR 1130	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RM} (rep) V_{RM} (wkg) V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RM} (non-rep)	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_O	12.0									Amp
Peak Repetitive Forward Current (T_C = 150°C)	$I_{FM(rep)}$	75									Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, 1 msec < t < 8.3 ms)	I^2t	375									$A(rms)^2s$
Maximum Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +190									°C

ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
DC Forward Voltage Drop (I_F = 12.0 Adc, T_C = 25°C)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	0.5	mA

MR1120 thru MR1126, MR1128, MR1130 (continued)

THERMAL CHARACTERISTICS

Maximum Steady State DC Thermal Resistance, θ_{JC}: 2.5°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

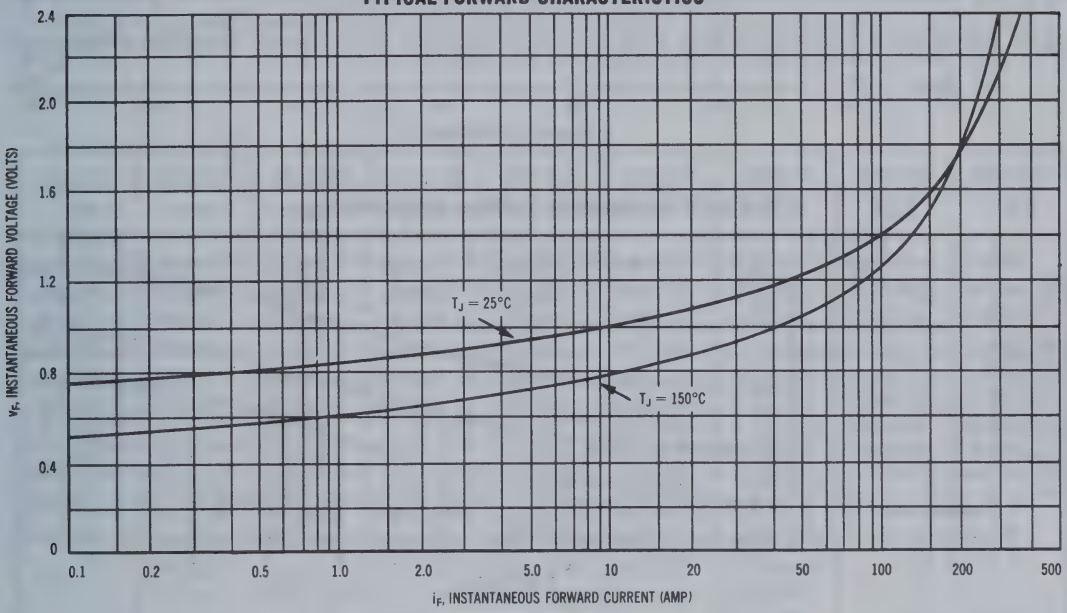
FINISH: All external surfaces corrosion-resistant and the terminal lug is readily solderable.

POLARITY: CATHODE-TO-CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR1120R).

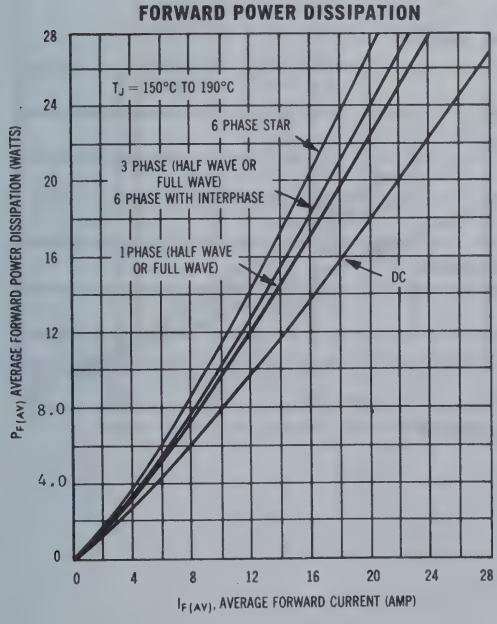
MOUNTING POSITIONS: Any

STUD TORQUE: 15 in-lbs maximum.

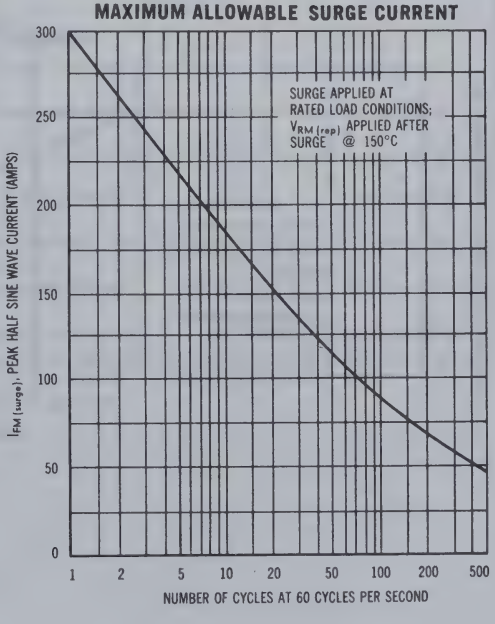
TYPICAL FORWARD CHARACTERISTICS



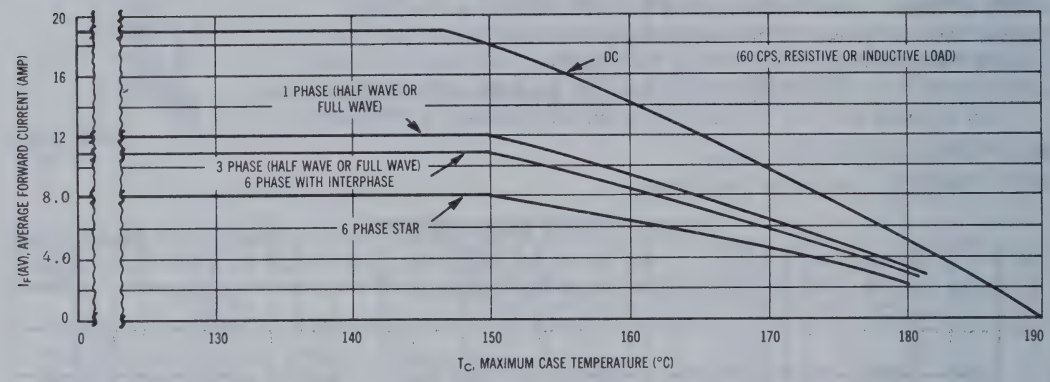
FORWARD POWER DISSIPATION



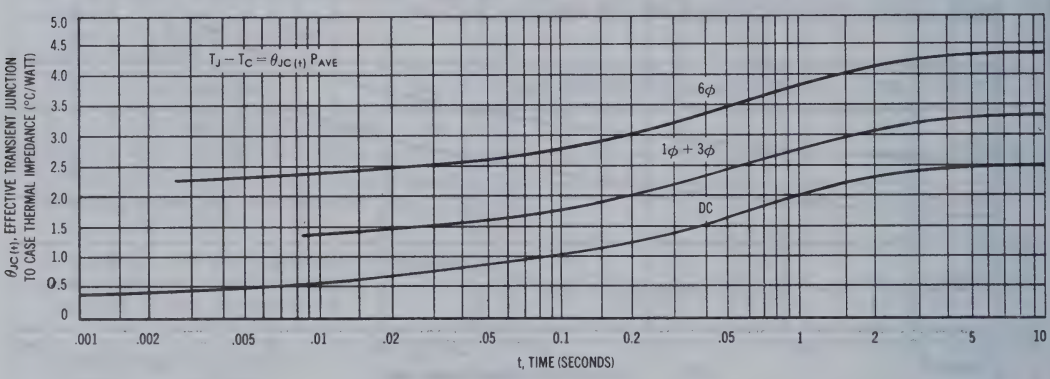
MAXIMUM ALLOWABLE SURGE CURRENT



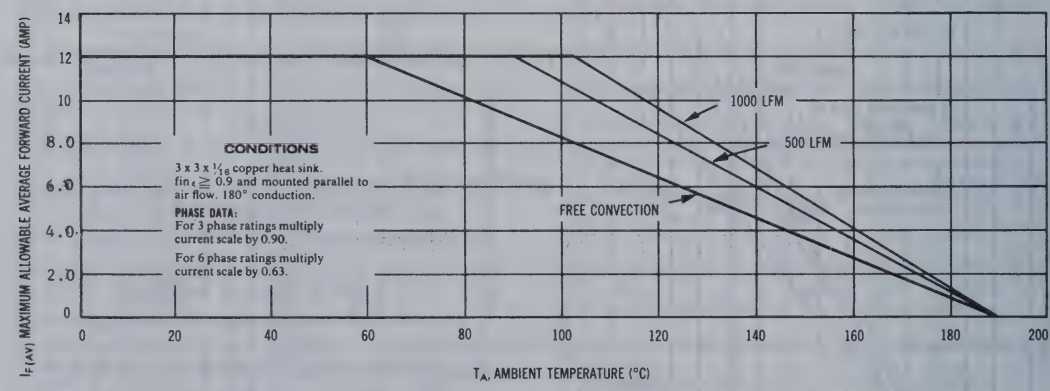
MAXIMUM CURRENT RATINGS



EFFECTIVE TRANSIENT THERMAL IMPEDANCE



CURRENT DERATING DATA



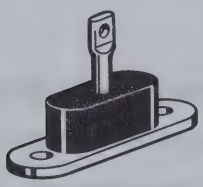
RECTIFIER SUBSTITUTION GUIDE

Due to its optimized design, this 12-ampere rectifier series (types MR1120 - MR1130) provides a high performance, economical solution to your specification and procurement requirements. Only nine types, covering the complete voltage range from 50 to 1000 volts, can substitute for a multitude of devices as typified in the table below. This table is only a guide and general reference to the EIA registered types which can be replaced; minor specification variations may exist.

MR1120 50V	MR1121 100V	MR1122 200V	MR1123 300V	MR1124 400V	MR1125 500V	MR1126 600V	MR1128 800V	MR1130 1000V
1N607	1N253	1N254	1N334	1N255	1N554	1N256	1N562	1N563
1N607A	1N338	1N336	1N335	1N332	1N613	1N555	1N3649	1N3650
1N1199	1N339	1N337	1N343	1N333	1N613A	1N614	1N3670	1N3672
1N1199A	1N340	1N345	1N344	1N341	1N1119	1N614A	1N3670A	1N3672A
1N1341	1N348	1N346	1N552	1N342	1N1127	1N1120	1N3671	1N3673
1N1341A	1N349	1N551	1N611	1N553	1N1127A	1N1128	1N3671A	1N3673A
1N1537	1N550	1N609	1N611A	1N612	1N1205	1N1128A	1N3987	1N3989
1N1612	1N608	1N609A	1N1117	1N612A	1N1205A	1N1206	1N3988	1N3990
	1N608A	1N610	1N1125	1N1118	1N1347	1N1206A		
	1N1115	1N610A	1N1125A	1N1126	1N1347A	1N1348		
	1N1200	1N1116	1N1203	1N1126A	1N1543	1N1348A		
	1N1200A	1N1124	1N1203A	1N1204	1N3573	1N1544		
	1N1342	1N1124A	1N1345A	1N1204A		1N1616		
	1N1342A	1N1201	1N1541	1N1346		1N3574		
	1N1538	1N1201A	1N3571	1N1346A				
	1N1613	1N1202		1N1542				
	1N3569	1N1202A		1N1615				
		1N1343		1N3572				
		1N1343A						
		1N1344						
		1N1344A						
		1N1539						
		1N1540						
		1N1614						
		1N3570						

NOTE: While the MR1120 through MR1130 are preferred device types, the above listed EIA types are also available upon request.

MR1200 thru MR1203 (SILICON)
MR1205, MR1207 thru MR1209



CASE 100

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1200	MR 1201	MR 1202	MR 1203	MR 1205	MR 1207	MR 1208	MR 1209	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 150°C	I_O	50								Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	800 (for 1/2 cycle) 500 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	1,300								$A_{(rms)}{}^2s$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	10	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.60	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATION:

MR1200FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.

Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1205FLR.

MOUNTING POSITION: Any.

MOUNTING BOLT TORQUES:

For Flat Mounted "FL" rectifiers use 8-32 bolts torqued to 30 in-lbs min., 40 in-lbs max. Use an alternating procedure when torquing the two bolts and do not tighten one bolt completely without tightening the other.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

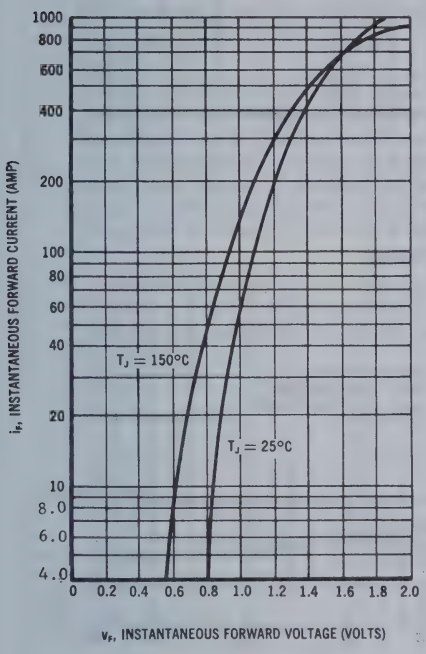


FIGURE 2 — FORWARD POWER DISSIPATION

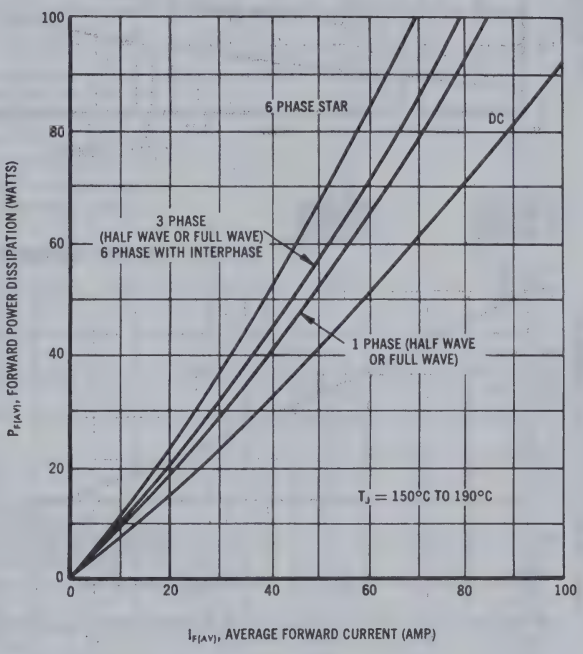


FIGURE 3 — MAXIMUM CURRENT RATINGS

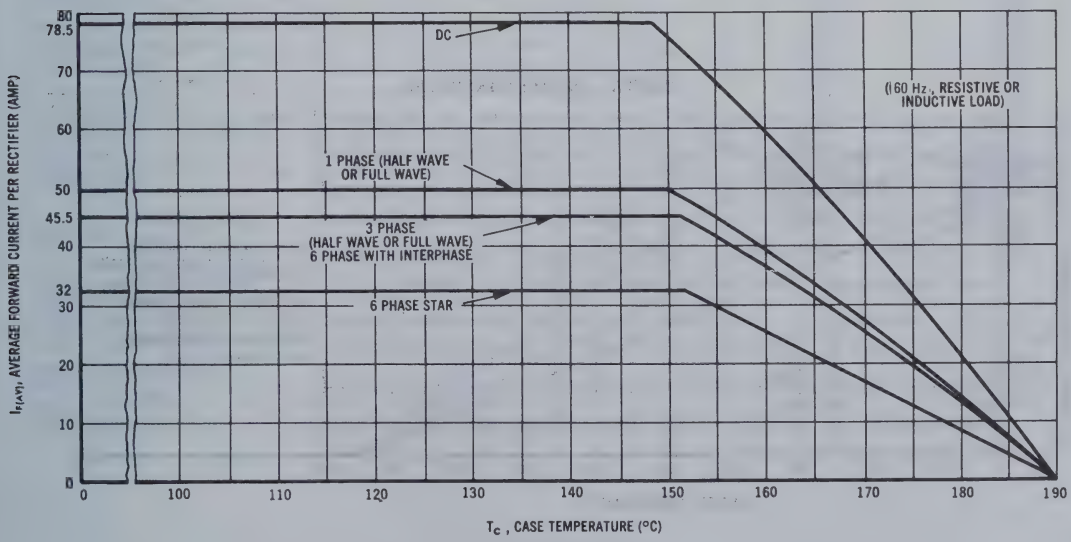


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

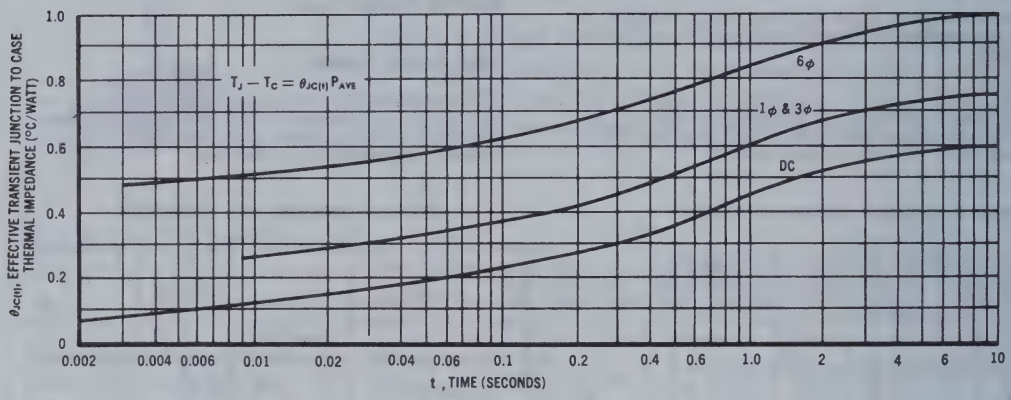


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

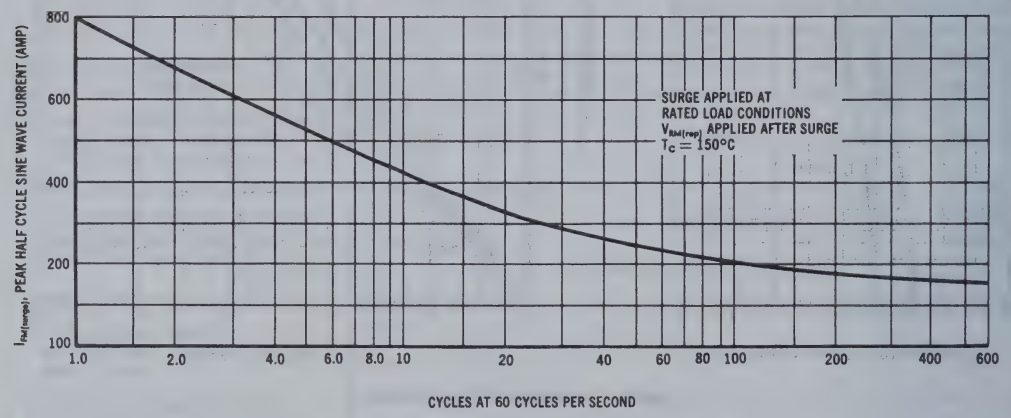
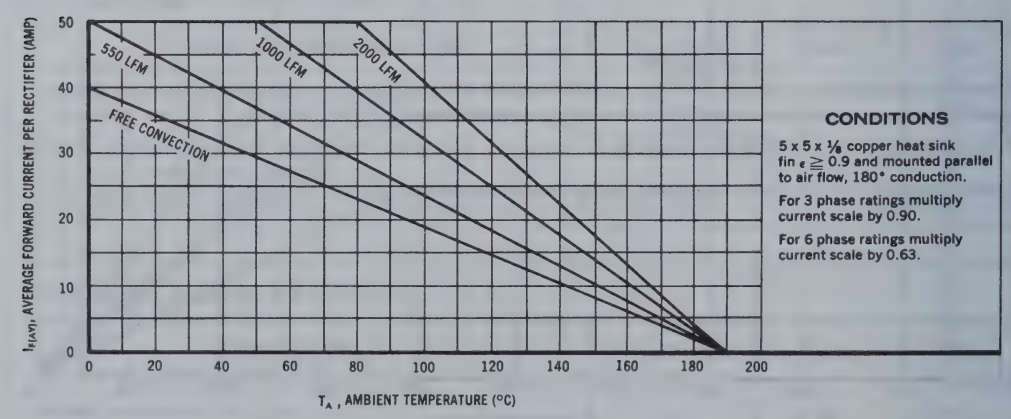


FIGURE 6 — CURRENT DERATING DATA



MR1210 thru MR1219 (SILICON)
MR1810 thru MR1819

UNIQUE, MULTI-CELL RECTIFIERS OFFERING HIGHEST ORDER OF RELIABILITY IN POWER APPLICATIONS

Designers Data for "Worst Case" Conditions

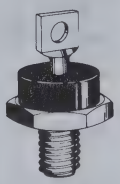
Motorola DESIGNERS Data Sheets are prepared to facilitate "worst-case" circuit design entirely from information presented on these pages. To do this, the usual typical curves which provided some guidance to the engineer, have been supplemented by limit curves which are directly applicable to "worst-case" rectifier circuit design. Limit curves represent boundaries on parameters and does not necessarily indicate typical rectifier behavior.

HIGH-CURRENT SILICON RECTIFIERS

80/100 AMPERE
50-600 VOLTS
DIFFUSED JUNCTIONS



MR1210SL thru MR1219SL
CASE 167



MR1810SL thru MR1819SL
CASE 189

MAXIMUM RATINGS

Rating	Symbol	MR 1210	MR 1211	MR 1212	MR 1213	MR 1214	MR 1215	MR 1216	MR 1217	MR 1218	MR 1219	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	MR 1810	MR 1811	MR 1812	MR 1813	MR 1814	MR 1815	MR 1816	MR 1817	MR 1818	MR 1819	
		50	100	150	200	250	300	350	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 Hz peak)	$V_{RM(non-rep)}$	100	200	250	300	350	400	450	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	175	210	245	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) $T_C = 135^oC$ $T_C = 150^oC$	I_O	100 80										Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) $T_C = 150^oC$	$I_{FM(surge)}$	2,000 (for 1/2 cycle) 1,200 (for six consecutive cycles)										Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	8,300										A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190										^oC

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, $T_C = 150^oC$)	$V_{F(AV)}$	0.4	Volt
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, $T_C = 150^oC$)	$I_{R(AV)}$	15	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.40	$^oC/Watt$



MR1210SB thru MR1219SB
CASE 168



MR1810SB thru MR1819SB
CASE 190

FIGURE 1 – MAXIMUM FORWARD VOLTAGE DROP

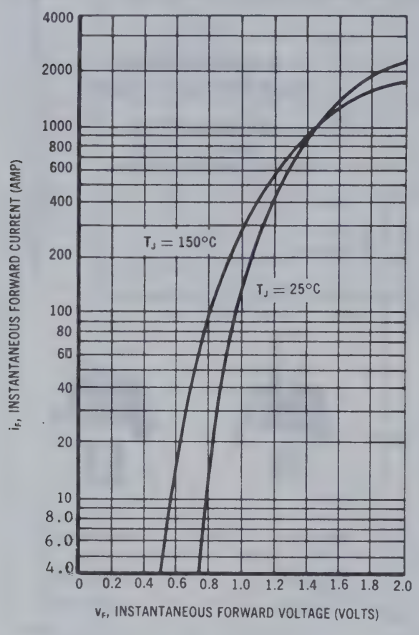


FIGURE 2 – MAXIMUM FORWARD POWER DISSIPATION

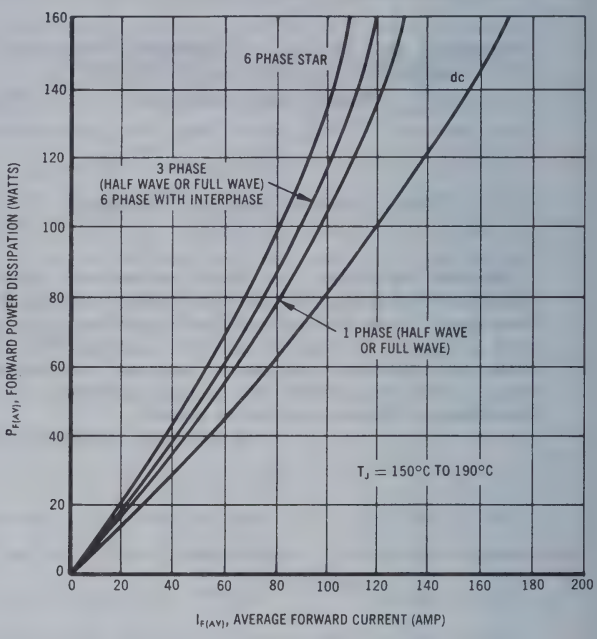


FIGURE 3 – MAXIMUM CURRENT RATINGS

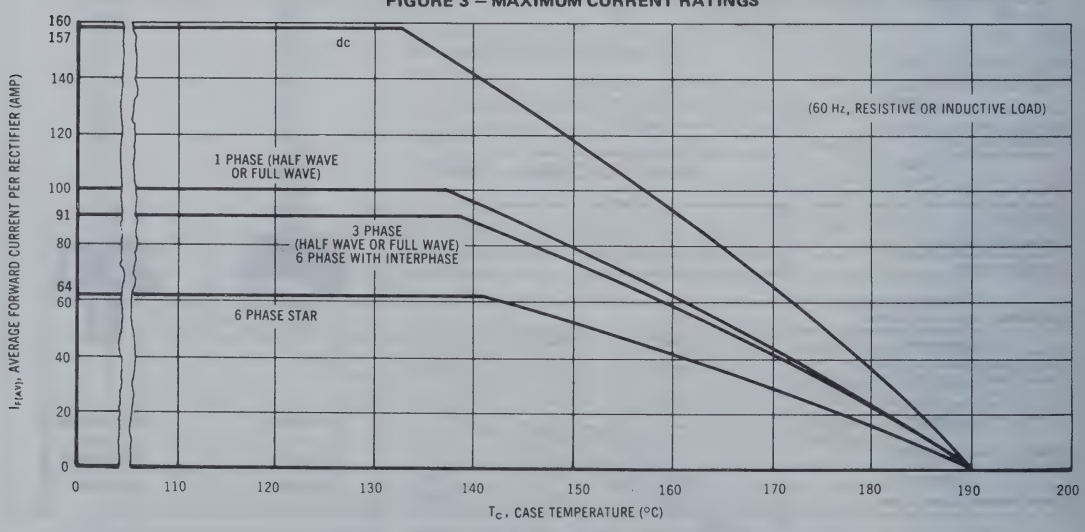


FIGURE 4 – EFFECTIVE TRANSIENT THERMAL IMPEDANCE

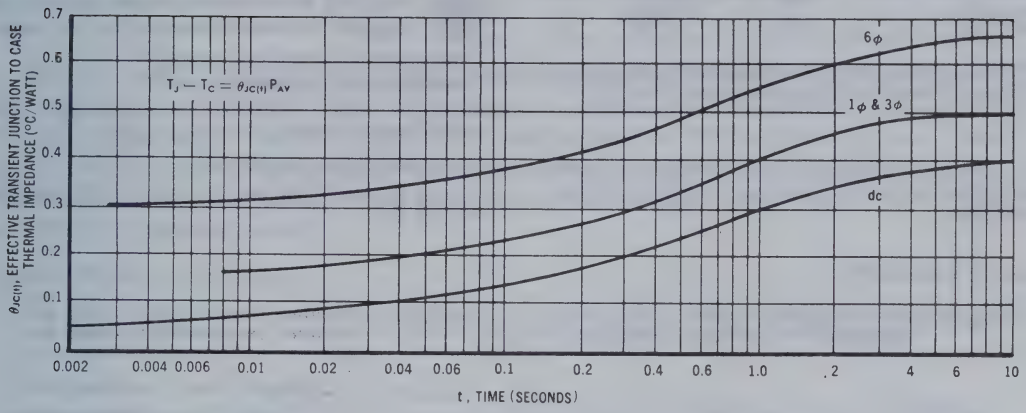


FIGURE 5 – MAXIMUM ALLOWABLE SURGE CURRENT

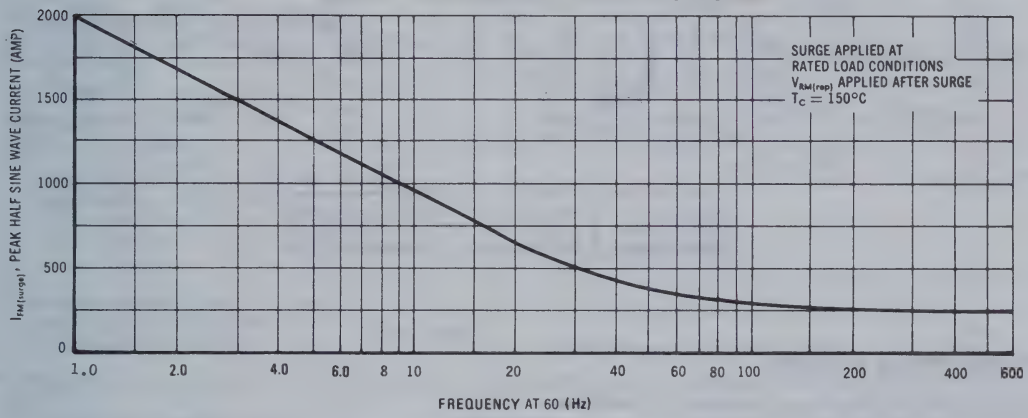
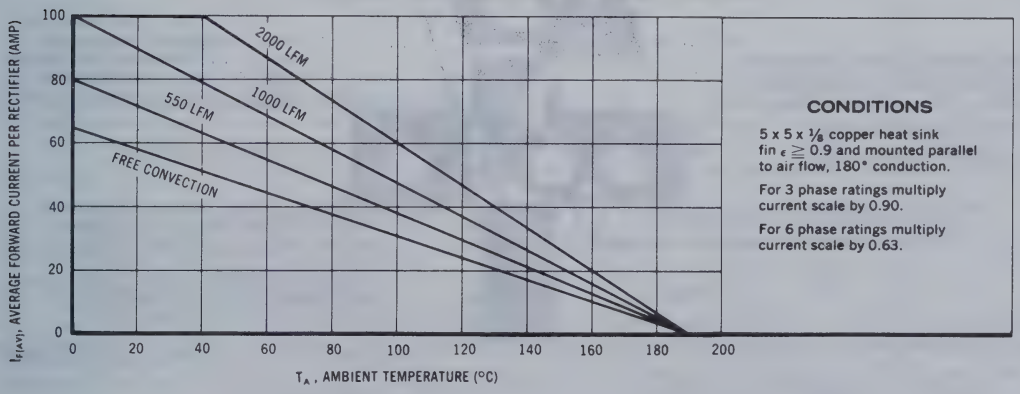


FIGURE 6 – MAXIMUM CURRENT DERATING DATA



PACKAGE CONFIGURATIONS:

MR1210SB and MR1810SB rectifiers are designed for stud mounting and have a flexible braided lead terminal (See Outline 1).

MR1210SL and MR1810SL rectifiers are designed for stud mounting and have a solid lug terminal (See Outline 2).

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells

POLARITY:

Standard polarity devices are CATHODE TO CASE. Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1215SLR. These devices have a molded plastic top for mechanical strength and seal. The color of the plastic indicates the polarity of the cells inside.

"RED PLASTIC CATHODE TO CASE"
"BLACK PLASTIC ANODE TO CASE"

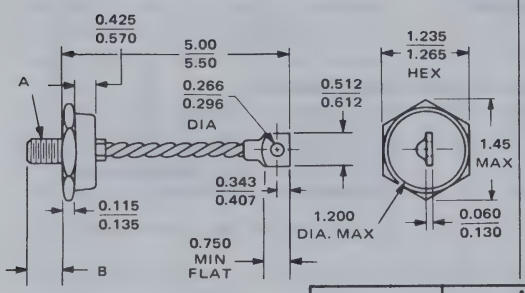
MOUNTING POSITION: Any

STUD MOUNTING TORQUES:

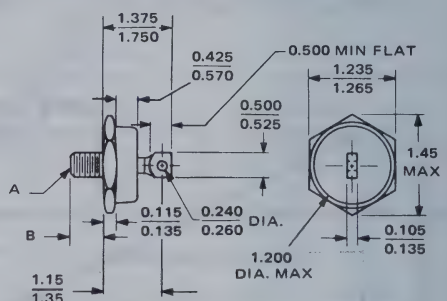
For Stud Mounted "SB" and "SL" rectifiers, 25 in-lb min., 30 in-lb max.

OUTLINE DIMENSIONS

OUTLINE 1 – MR1210SB THRU MR1219SB – CASE 168
MR1810SB THRU MR1819SB – CASE 190



OUTLINE 2 – MR1210SL THRU MR1219SL – CASE 167
MR1810SL THRU MR1819SL – CASE 189



	A	B
MR1210 Series	No 10-32-UNF-2A	0.424/0.500
MR1810 Series	3/8-24-UNF-2A	0.593/0.657

CONSTRUCTIONAL FEATURES

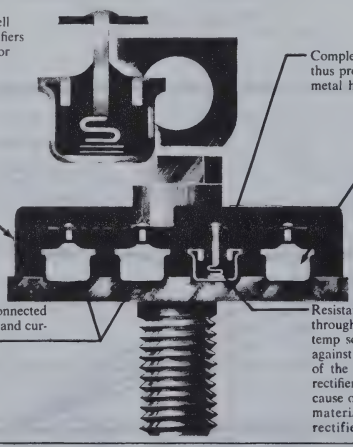
Motorola's advanced and unique double-case, multiple cell construction offers numerous advantages which result in rectifiers possessing "designed-in" ruggedness, reliability and superior performance characteristics.

Void-free, molded external case for added mechanical strength and electrical isolation in addition to being corrosion resistant. Color coding of the external case provides easy polarity identification.

RED — CATHODE TO CASE

BLACK — ANODE TO CASE

Plated copper base and/or stud integrally connected to the inner cases for optimum heat transfer and current balance between cells.



Complete seal strength is afforded by the outer case thus preventing any excessive stress on the glass-to-metal hermetic inner seal.

Internal, hermetically sealed, welded metal case rectifier cells. All individual cells are specially processed, tested and matched for similarity of forward characteristics to assure balanced current sharing and reliable parallel operation.

Resistance to thermal fatigue of each cell is assured through the use of double back-up discs and high temp solder construction to protect the silicon die against stresses. In addition, the small junction areas of the individual paralleled cells result in a total rectifier which can better resist thermal fatigue because of the smaller excursion of dissimilar bonded materials as opposed to a large single-junction rectifier.

MR1220 thru MR1223 (SILICON)
MR1225, MR1227 thru MR1229



Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1220	MR 1221	MR 1222	MR 1223	MR 1225	MR 1227	MR 1228	MR 1229	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 135°C T_C = 150°C	I_O	200 160								Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	3,600 (for 1/2 cycle) 2,000 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	27,000								A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	20	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.20	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1220SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1220FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1220SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1220FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.
Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1225FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FB" and "FL" rectifiers use No. 10 bolts torqued to 25 in-lbs min., 30 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

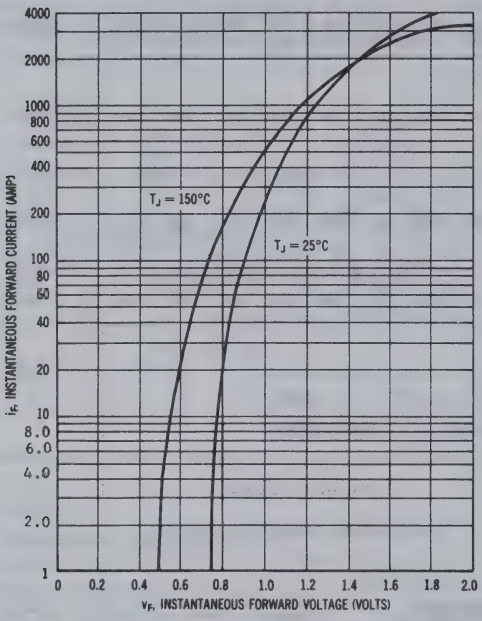


FIGURE 2 — FORWARD POWER DISSIPATION

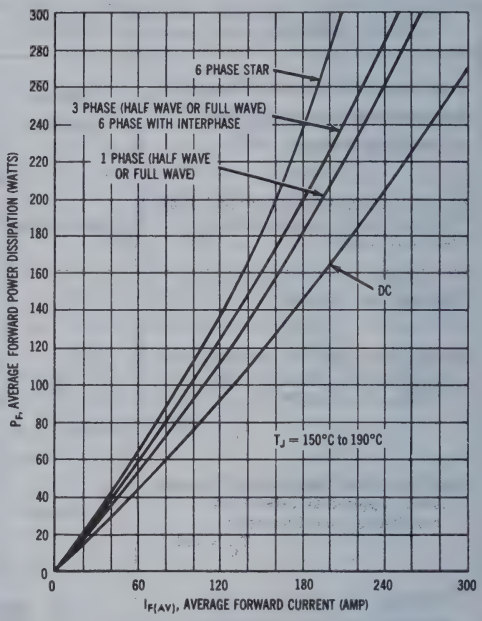


FIGURE 3 — MAXIMUM CURRENT RATING

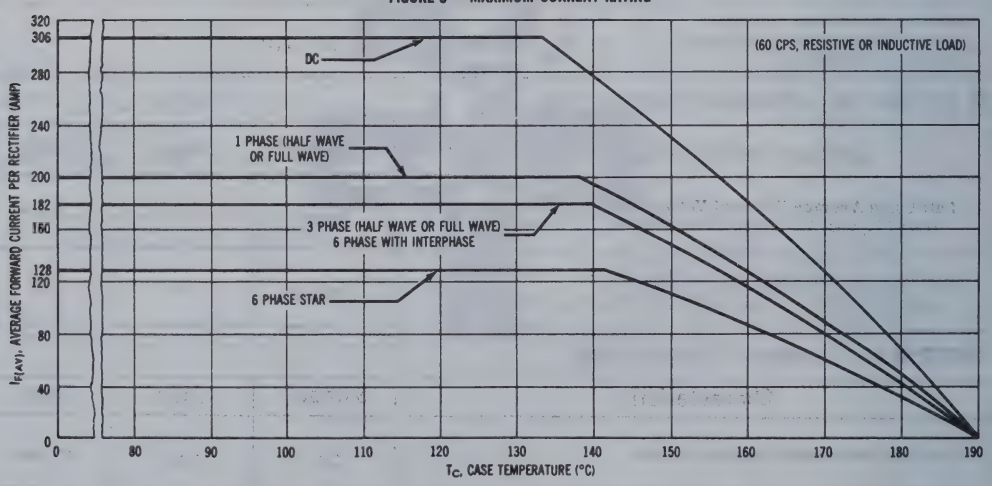


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

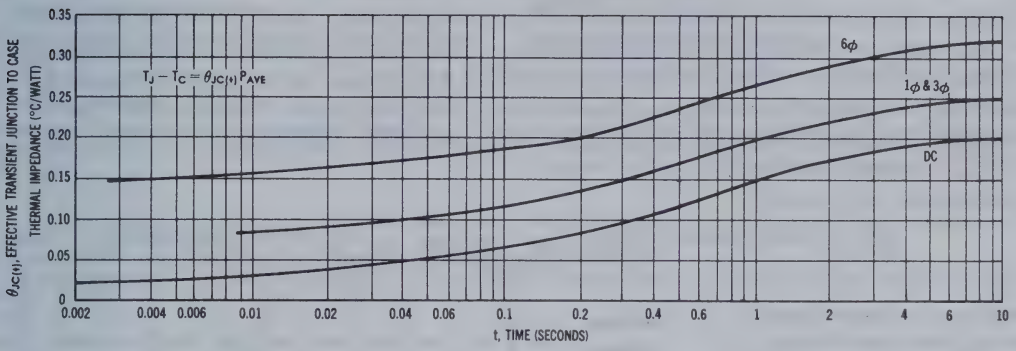


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

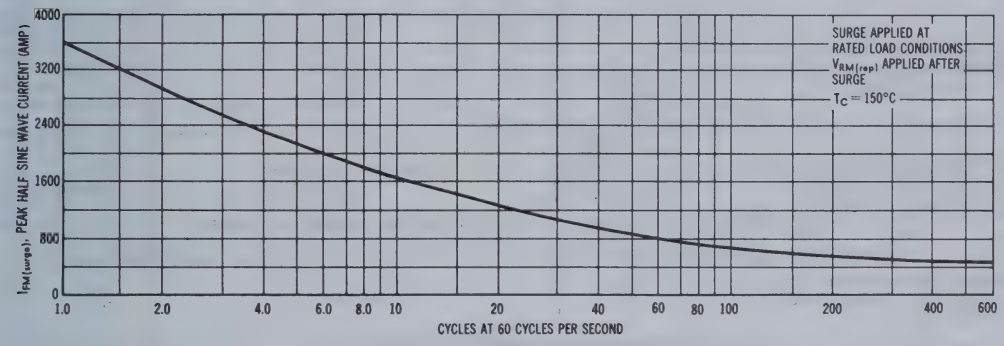
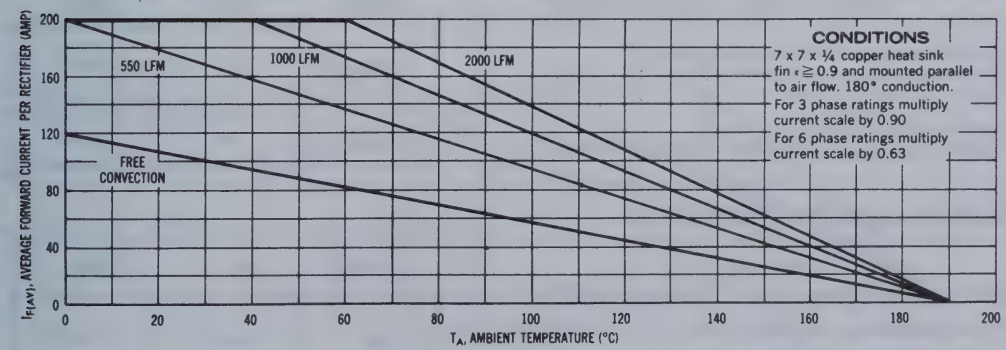
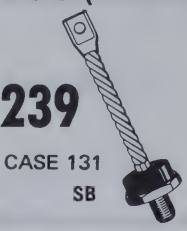


FIGURE 6 — CURRENT DERATING DATA



MR1230 thru MR1233 (SILICON)
MR1235
MR1237 thru MR1239


CASE 131
SB


CASE 138
FB


SL CASE 127


FL CASE 134

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1230	MR 1231	MR 1232	MR 1233	MR 1235	MR 1237	MR 1238	MR 1239	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 135°C T_C = 150°C	I_O	300 240								Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	5,000 (for 1/2 cycle) 3,000 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	52,000								A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	35	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.12	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1230SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1230FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1230SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1230FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.
Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1235FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FB" and "FL" rectifiers use ¼ inch bolts torqued to 60 in-lbs min., 80 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

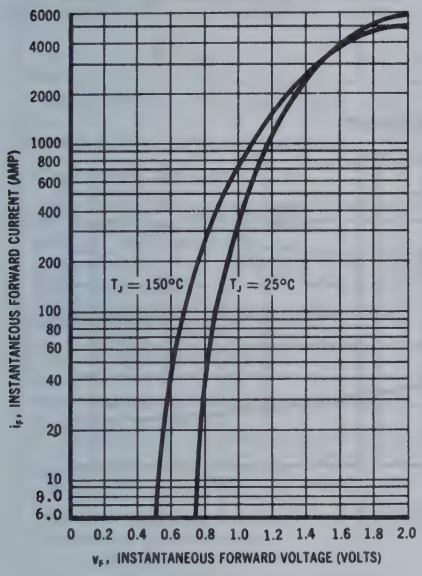


FIGURE 2 — FORWARD POWER DISSIPATION

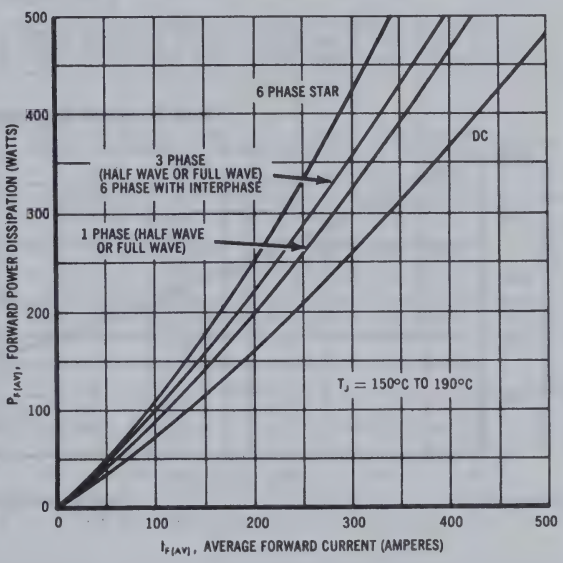


FIGURE 3 — MAXIMUM CURRENT RATINGS

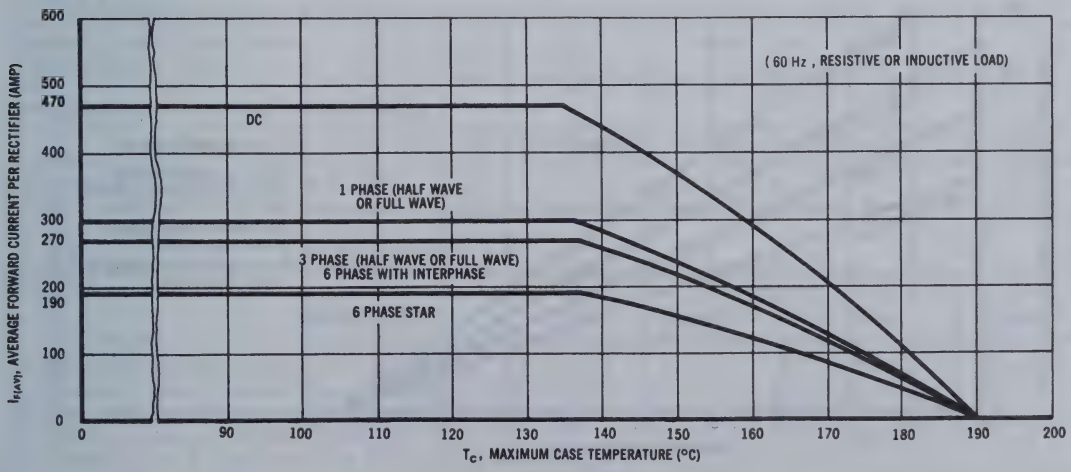


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

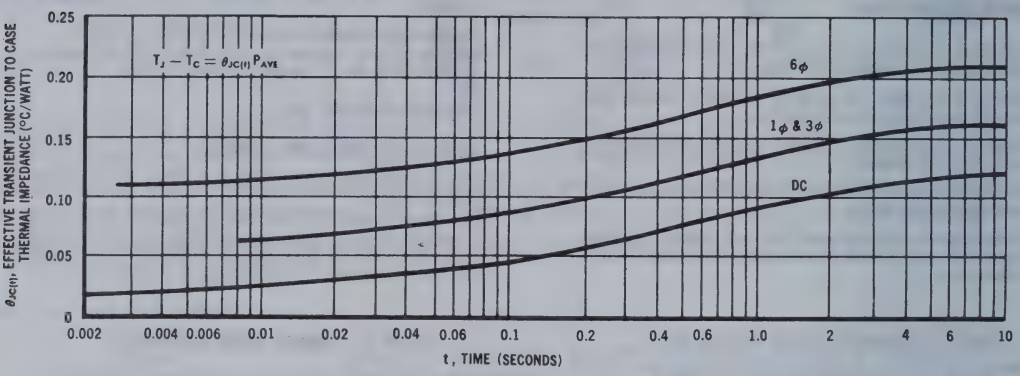


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

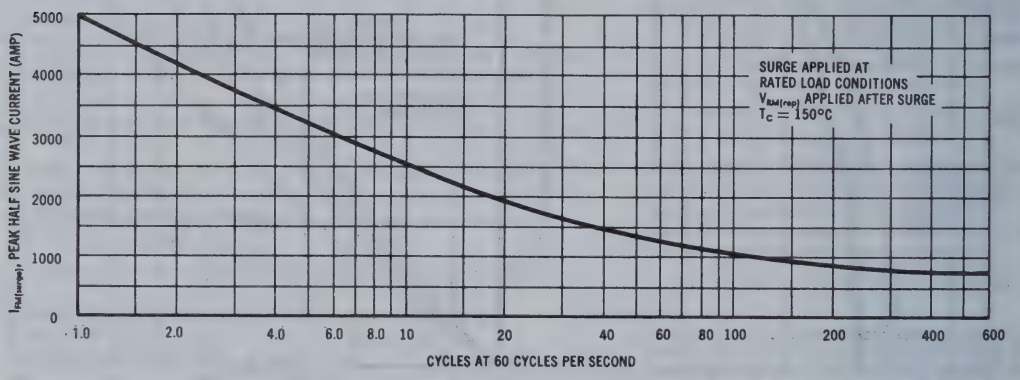
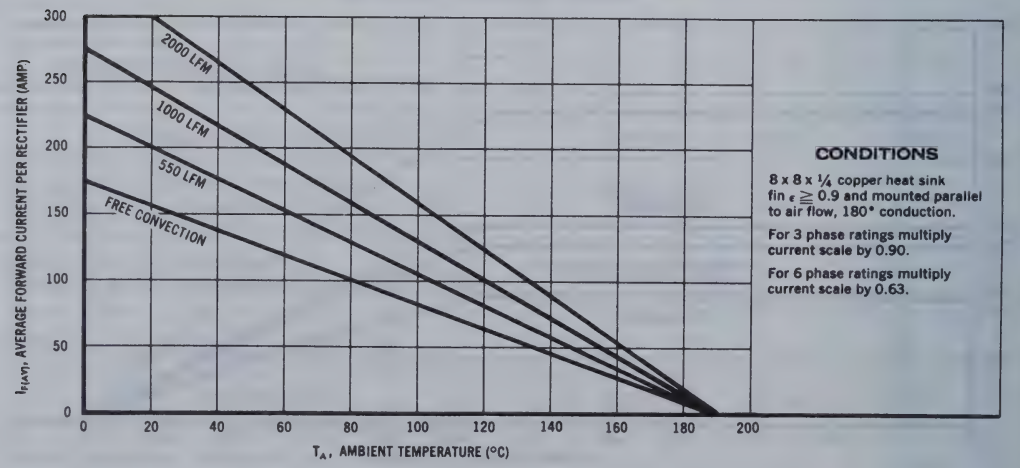


FIGURE 6 — CURRENT DERATING DATA



MR1240 thru MR1243 (SILICON)
MR1245, MR1247 thru MR1249


CASE 132
SB


CASE 139
FB


SL CASE 128


FL CASE 135

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1240	MR 1241	MR 1242	MR 1243	MR 1245	MR 1247	MR 1248	MR 1249	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150° C	I_O	400								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150° C)	$I_{FM(surge)}$	8,000 (for 1/2 cycle) 4,500 (for six consecutive 1/2 cycles)								Amperes
I^2t Rating (non-repetitive for t greater than 1.0 ms and less than 8.3 ms)	I^2t	133,000								A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

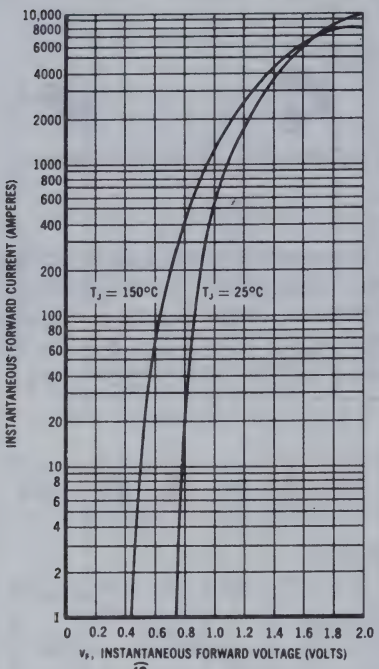
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.075	°C/W

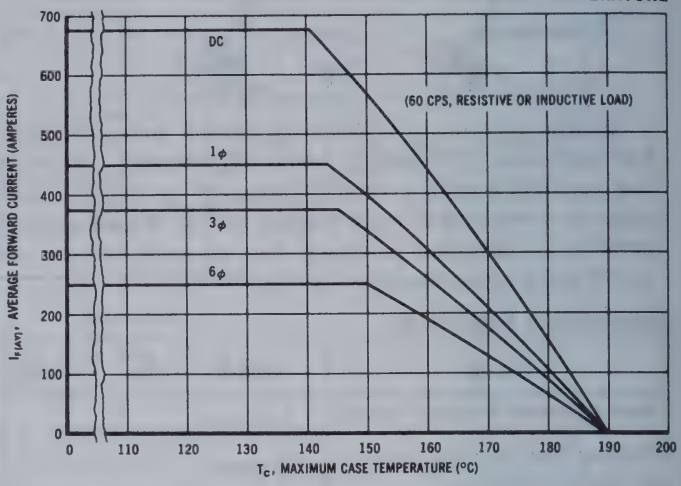
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase 60 Hz, T_C = 150° C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase 60 Hz, T_C = 150° C)	$I_{R(AV)}$	50	mA

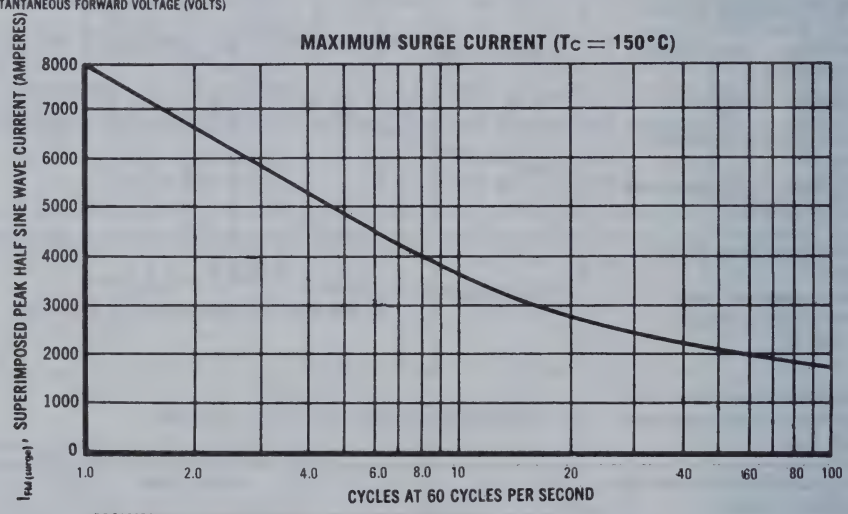
FORWARD VOLTAGE CHARACTERISTICS



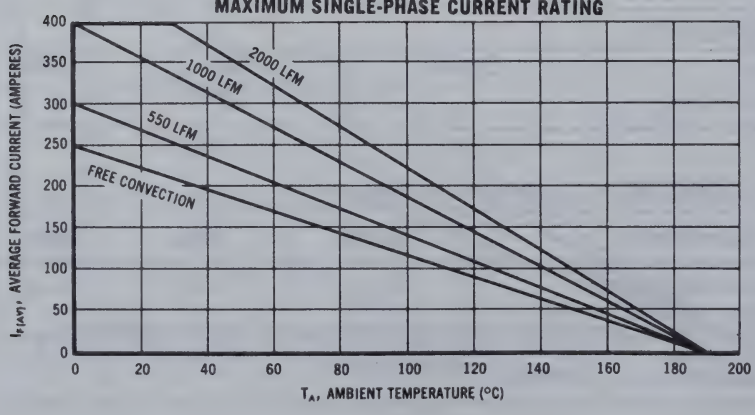
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT ($T_C = 150°C$)



MAXIMUM SINGLE-PHASE CURRENT RATING



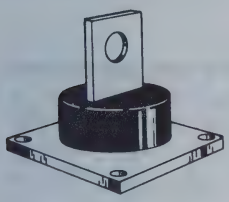
CONDITIONS

8 x 8 x ¼ copper heat sink fin$\epsilon \geqq 0.9$ and mounted parallel to air flow. 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1260 thru MR1263 (SILICON)
MR1265, MR1267 thru MR1269



CASE 136

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1260	MR 1261	MR 1262	MR 1263	MR 1265	MR 1267	MR 1268	MR 1269	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	650								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	12,000 (for 1/2 cycle) 8,000 (for six consecutive 1/2 cycles)								Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	300,000								A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

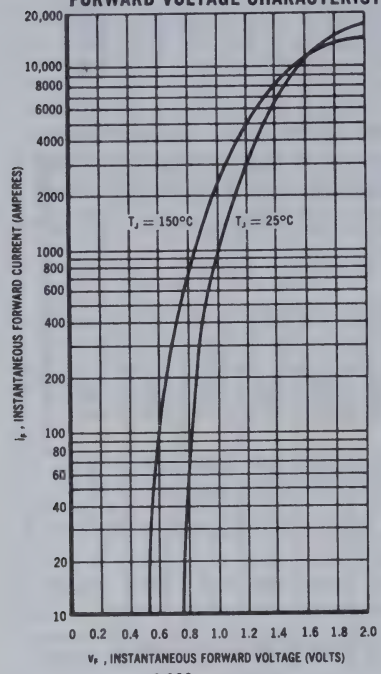
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.045	°C/Watt

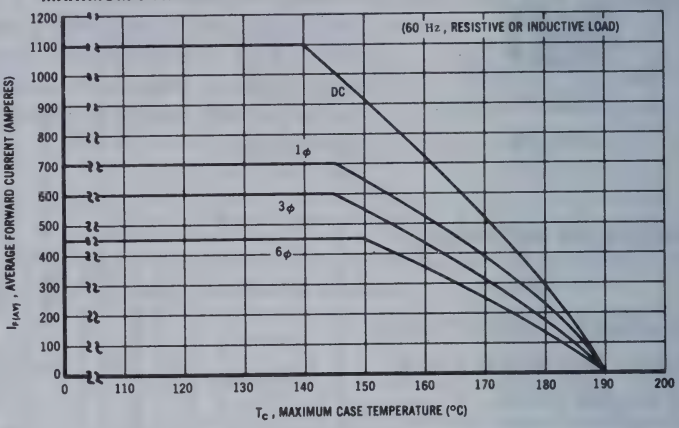
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	100	mA

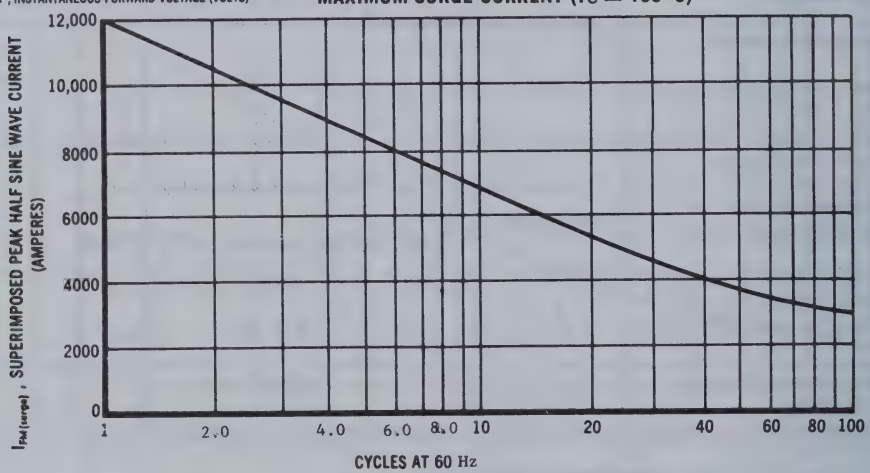
FORWARD VOLTAGE CHARACTERISTICS



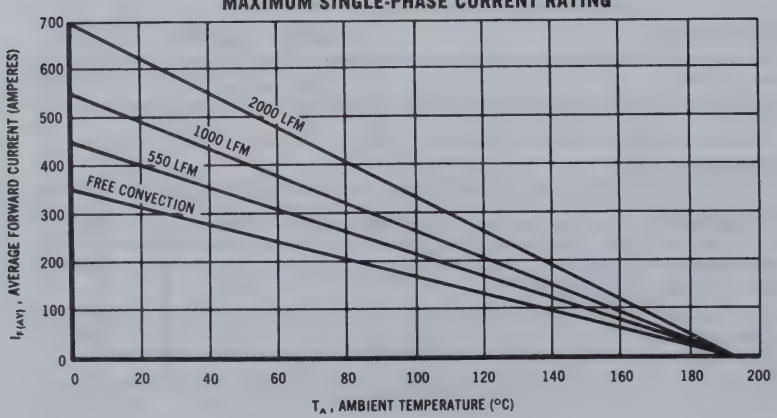
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT ($T_C = 150°C$)



MAXIMUM SINGLE-PHASE CURRENT RATING



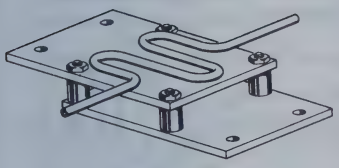
CONDITIONS

10 x 10 x ¼ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1290 thru MR1293 (SILICON)
MR1295, MR1297 thru MR1299



CASE 105

Silicon power rectifiers designed with multi-cell construction for extreme reliability and ruggedness. Standard polarity is cathode-to-water-cooled case, but reverse polarity devices are available designated by an "R" suffix. i.e. MR1295R

MAXIMUM RATINGS

Rating	Symbol	MR 1290	MR 1291	MR 1292	MR 1293	MR 1295	MR 1297	MR 1298	MR 1299	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Continuous Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	1000								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	18,000 (for 1/2 cycle) 13,500 (for six consecutive 1/2 cycles)								Amperes
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

Case Temperature Reference Point: T_C measured at center edge of the water cooled mounting bus.

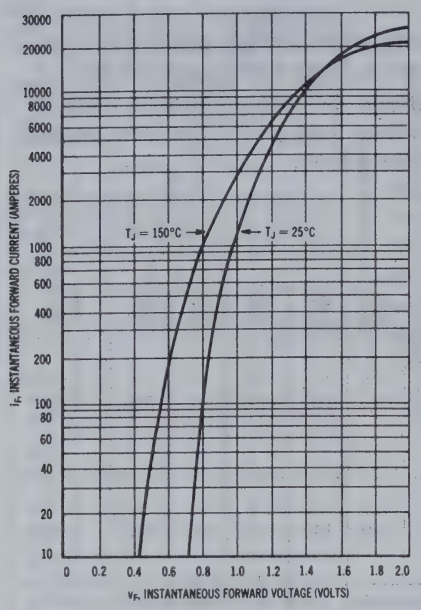
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case DC 1 and 3 phase 6 phase	θ_{JC}	 0.035 0.045 0.060	°C/Watt

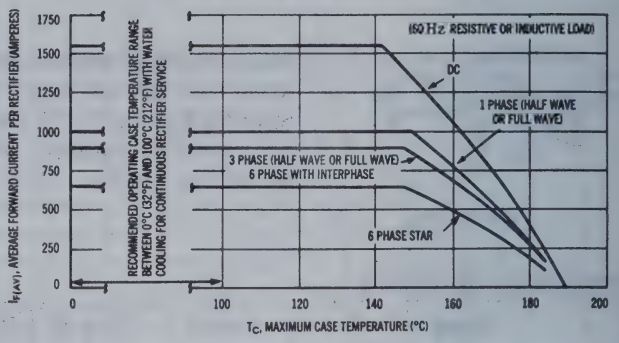
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	0.2	Amperes

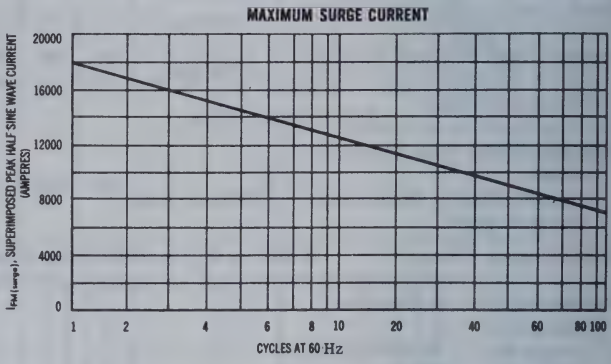
FORWARD VOLTAGE CHARACTERISTICS



MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE (100% DUTY)



MAXIMUM SURGE CURRENT



TYPICAL COOLING RATES AT RATED LOAD CONDITIONS

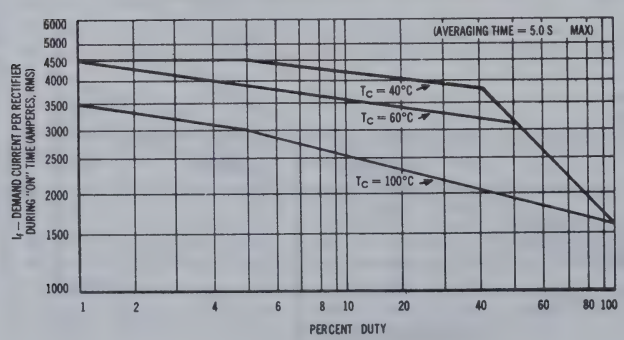
Inlet Water Temperature (°C)	Minimum Water Flow Required (Gallons/Hour)	Approx. Water Temp. Rise at Specified Flow Rate (°C)
15	2	10
50	5	8
75	10	5

NOTE: Water flow rates may be decreased at lighter load demands provided maximum case temperatures are not exceeded. In some applications where cooling systems are operated in series, it may be desirable to increase flow rates in order to minimize water temperature rises.

COOLING REQUIREMENTS

Type of Cooling — Water
Min Inlet Water Temp. — 0°C
Max Inlet Water Temp. — 75°C

MAXIMUM RMS DEMAND CURRENT versus PERCENT DUTY



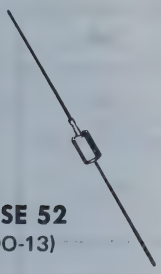
NOTE:

Curves apply to normal rectifier service conditions with maintained Rectifier Case Temperature (T_C) equal to or less than the values specified.

To determine the Maximum Average Current [$I_{F(AV)}$] per rectifier, multiply the RMS Current [I_f] rating by the factor given for the operating condition.

- $I_{F(AV)} = .64I_f$ for Single Phase
- $I_{F(AV)} = .57I_f$ for Three Phase and Six Phase with interphase
- $I_{F(AV)} = .40I_f$ for Six Phase Star

MR1337-1 thru MR1337-5 (SILICON)



CASE 52
(DO-13)

Fast recovery silicon rectifiers designed for high-frequency power supply, inverter, and converter applications. Typical recovery time of 100 nsec extends practical frequency limit of current rectification to more than 300,000 Hz thus permitting the design of power supplies with smaller, lighter, and less expensive associated components.

MAXIMUM RATINGS

Rating	Symbol	MR 1337-1	MR 1337-2	MR 1337-3	MR 1337-4	MR 1337-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Rectified Forward Current (single-phase resistive load) T_A=25°C Figure 2 T_A=75°C	I_O	1.0 0.75					Amp
Non-Repetitive Peak Surge Current Figure 3 (superimposed on rated current at rated voltage, T_A = 75 °C)	$I_{FM(surge)}$	30					Amp
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	4.0					Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	3.75					$A_{(rms)}^2s$
Maximum Junction Operating Temperature Range	T_J	-65 to +150					°C
Maximum Case Storage Temperature Range	T_{stg}	-65 to +175					
Maximum Steady State DC Thermal Resistance	θ_{JA}	100					°C/Watt

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

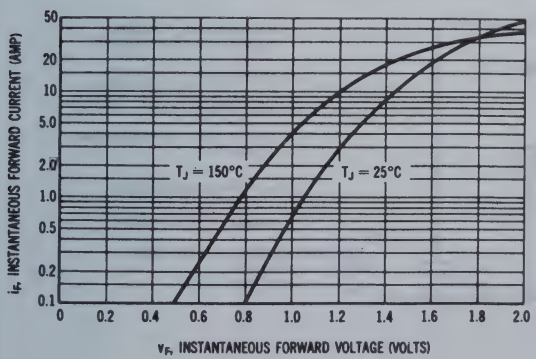
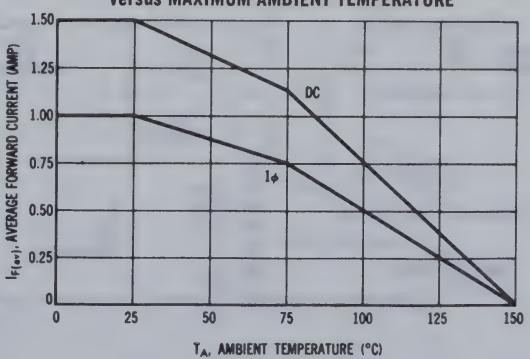


FIGURE 2 — MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE

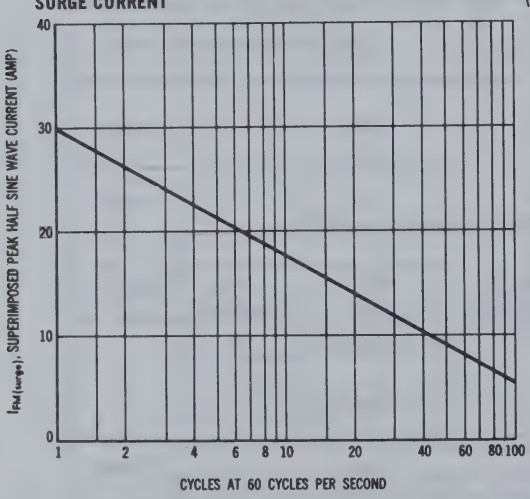


MR1337-1 thru MR1337-5 (continued)

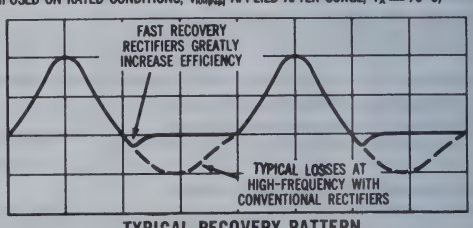
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.1	Vdc
Full Cycle Average Forward Voltage Drop (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
Full Cycle Average Reverse Current (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, single phase)	$I_{R(AV)}$	0.75	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.25	mA
Maximum Reverse Recovery Time (I_F = 1 Amp min)	t_{rr}	200	ns
Maximum Overshoot Current	I_{os}	2.0	Amp

FIGURE 3 — MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT



(SUPERIMPOSED ON RATED CONDITIONS, $V_{RM(rep)}$ APPLIED AFTER SURGE, T_A = 75°C)



TYPICAL RECOVERY PATTERN

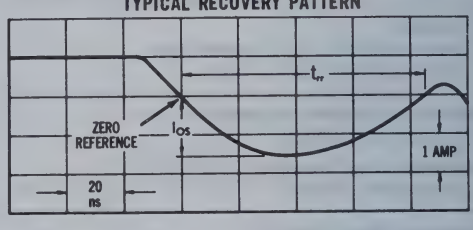
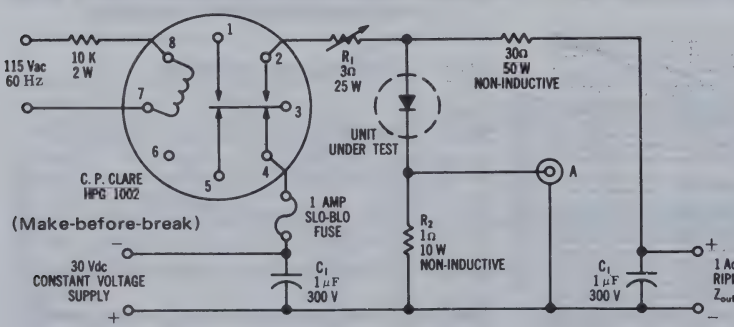


FIGURE 4 — t_{rr} TEST CIRCUIT



A — TEKTRONIX 545A, K PLUG-IN PRE-AMP, P6000 PROBE OR EQ

R_1 — ADJUSTED FOR 1.4Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER. INDUCTANCE ≈ 38 μh

R_2 — TEN 1 W, 10Ω, 1% CARBON COMP. IN PARALLEL

$T_A = 25 \begin{smallmatrix}+10\\-0\end{smallmatrix}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = ½Ω MAX, DC to 2 kHz

MR1366

For Specifications, See 1N3879 Data, Volume 1.

MR1376

For Specifications, See 1N3889 Data, Volume 1.

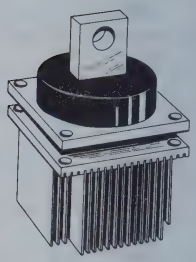
MR1386

For Specifications, See 1N3899 Data, Volume 1.

MR1396

For Specifications, See 1N3909 Data, Volume 1.

MR2080HA (SILICON)
thru
MR2084HA



CASE 159

Multi-Cell II, power rectifier diodes designed for high-current rectifier service. The MR2080HA through MR2084HA provide single-output, high-current dc with forced air cooling.

MAXIMUM DIODE RATINGS

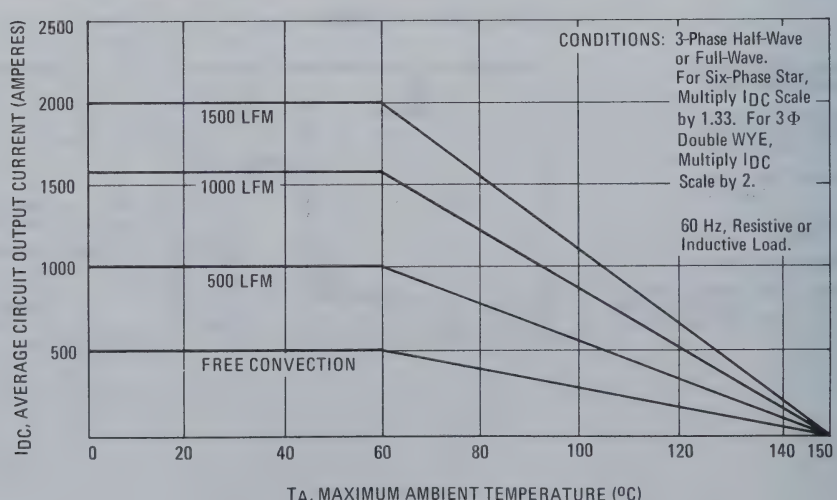
Rating	Symbol	MR2080HA	MR2081HA	MR2082HA	MR2083HA	MR2084HA	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	750					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	12,000 for 1/2 cycle 8,000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	3 Diodes Either Polarity	2,000 Amperes
Three-Phase Full-Wave (6-1-1-B)	6 Diodes Either Polarity or 3 Diodes Each Polarity	2,000 Amperes
Six-Phase Star (6-1-1-S)	6 Diodes Either Polarity	2,600 Amperes
Six-Phase with Interphase, 3Φ Double WYE (6-1-1-Y)	6 Diodes Either Polarity	4,000 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

FIGURE 1 – MAXIMUM CIRCUIT RATINGS



ELECTRICAL CHARACTERISTICS (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	80	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	4.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity devices are CATHODE-TO-CASE, reverse polarity devices are ANODE-TO-CASE and designated by an "R" suffix, i.e., MR2083HAR.

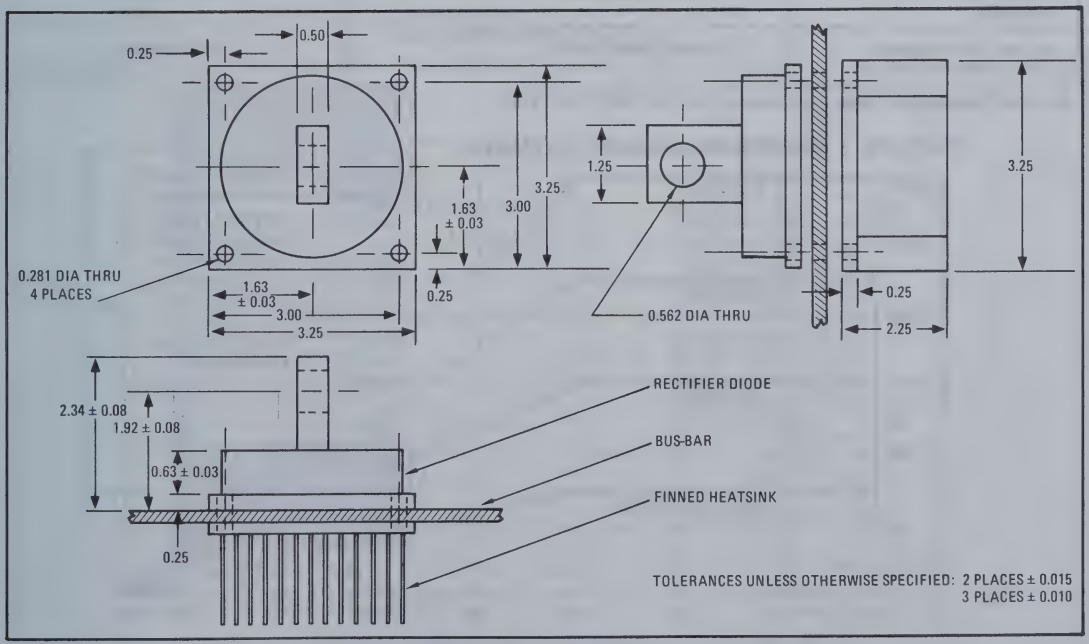
MOUNTING POSITION:

Cooling fins vertical for convection cooling or parallel to forced air flow.

MOUNTING CONFIGURATION:

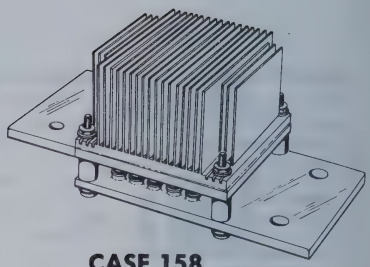
The MR2080HA series is designed to be mounted as an integral part of the current carrying bus-bar network of the rectifier system as shown in the outline dimensions. The rectifier diode and finned heatsink are supplied as two separate pieces under one common type number.

OUTLINE DIMENSIONS



MR2100HA (SILICON)
thru
MR2104HA

Multi-Cell II, power rectifier diodes designed for high-current rectifier service. The MR2100HA through MR2104HA provide single-output, high-current dc with forced air cooling.



CASE 158

MAXIMUM DIODE RATINGS

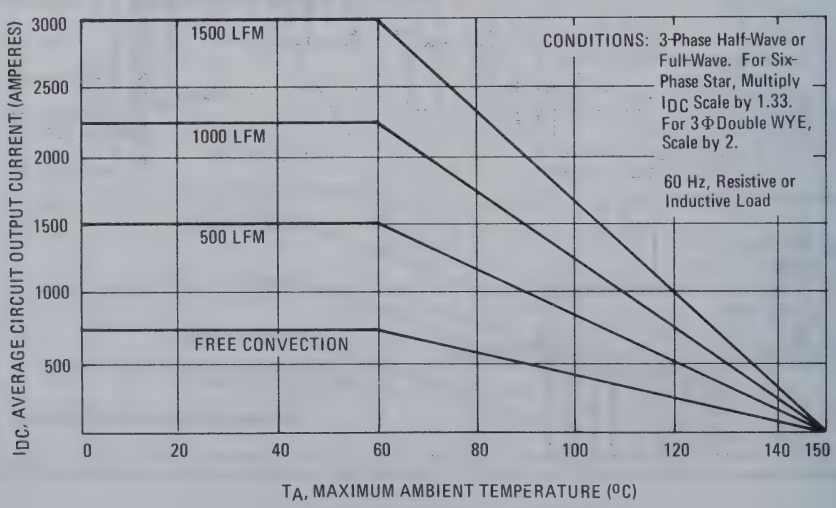
Rating	Symbol	MR2100HA	MR2101HA	MR2102HA	MR2103HA	MR2104HA	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	1,100					Amperes
Non-Repetitive Surge Current at Rated Conditions	$I_{FM(surge)}$	18,000 for 1/2 cycle 14,000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^{\circ}C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	3 Diodes Either Polarity	3,000 Amperes
Three-Phase Full-Wave (6-1-1-B)	6 Diodes Either Polarity or 3 Diodes Each Polarity	3,000 Amperes
Six-Phase Star (6-1-1-S)	6 Diodes Either Polarity	4,000 Amperes
Six-Phase with Interphase, 3 Φ Double WYE (6-1-1-Y)	6 Diodes Either Polarity	6,000 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

FIGURE 1 MAXIMUM CIRCUIT RATINGS



ELECTRICAL CHARACTERISTICS (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	100	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	5.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC (See Figure 1).

MECHANICAL CHARACTERISTICS

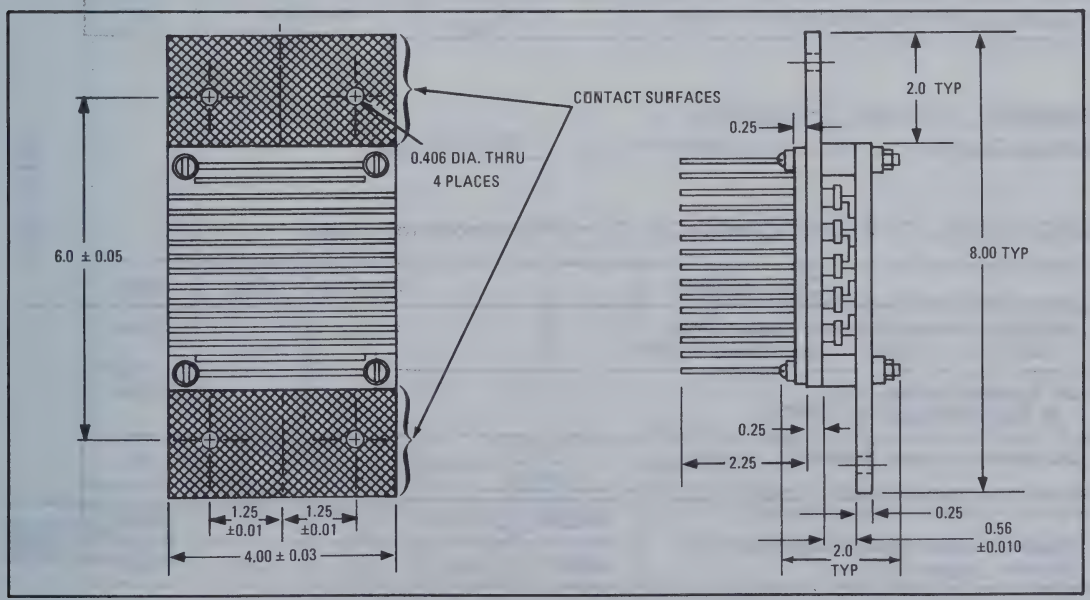
POLARITY:

Standard polarity devices are CATHODE-TO-FINNED BUS TERMINAL, reverse polarity devices are ANODE-TO-FINNED BUS TERMINAL and are designated by an "R" suffix, i.e., MR2102HAR.

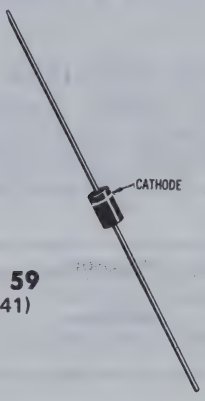
MOUNTING POSITION:

Bus terminals and cooling fins vertical for convection cooling or parallel to forced air flow.

OUTLINE DIMENSIONS



MR2266 (SILICON)
MR2273



CASE 59
(DO-41)

High-voltage, axial-lead, silicon rectifiers, designed for television "damper" diode service, feature subminiature packages, high current-handling capability, excellent reliability, and economy. Flame-proof silicone polymer case.

MAXIMUM RATINGS

Rating	Symbol	MR2273	MR2266	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	200	800	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	140	560	Volts
Average Rectified Forward Current (single-phase, resistive load, 60 Hz) (75°C Ambient) (100°C Ambient)	I_O	1.0 0.75	1.0 0.75	Amp
Peak Repetitive Forward Current (T_A = 25°C)	$I_{FM(rep)}$	10		Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 25°C)	$I_{FM(surge)}$	30 (for 1/2 cycle)		Amp
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		°C

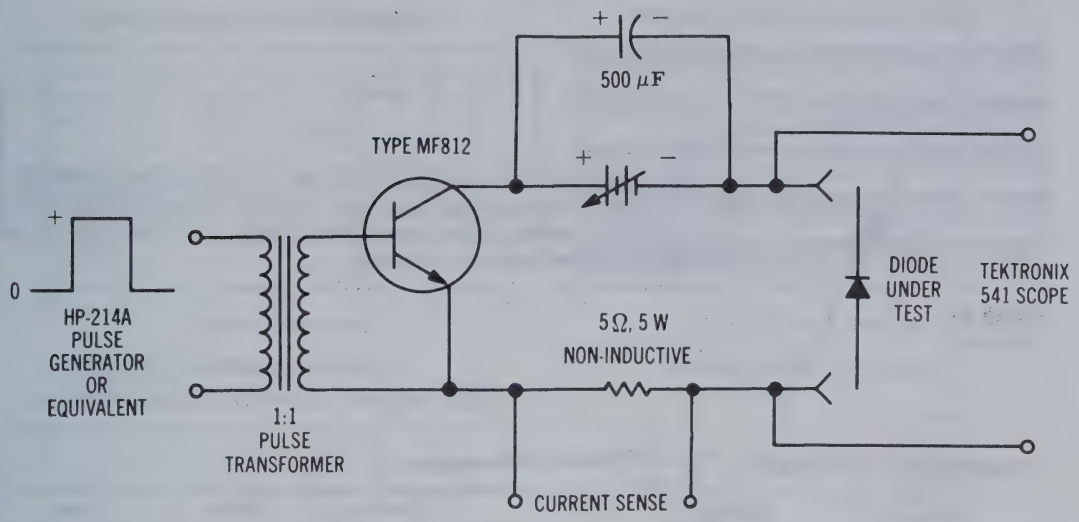
THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Max	Unit
Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C, sine wave operation)		$V_{F(AV)}$	0.8	Volts
DC Forward Voltage Drop (1 Amp Continuous DC, 25°C)		V_F	1.1	Volts
DC Reverse Current @ Rated V_r	(25°C) (100°C)	I_R	0.01 0.05	mA
			Typical	
Typical Forward Peak Voltage Overshoot (Figure 1, Figure 2)	MR2266, I_F = 2 A	V_{fp}	10	Volts
	MR2273, I_F = 5 A	V_{fp}	28	Volts

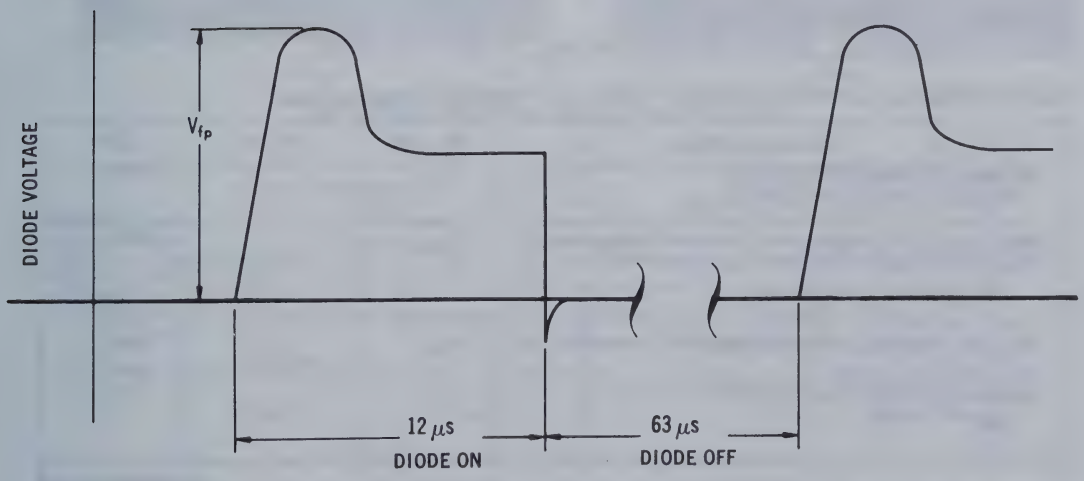
FIGURE 1 — FORWARD PEAK VOLTAGE OVERSHOOT TEST CIRCUIT



TEST PROCEDURE:

1. Adjust input pulse from generator to saturate MF812 transistor
2. Adjust battery voltage for the specified forward current after the voltage overshoot.
   I_F = 2 Amps, for MR2266
   I_F = 5 Amps, for MR2273
3. Read peak voltage overshoot across diode under test. (See Waveform Diagram).

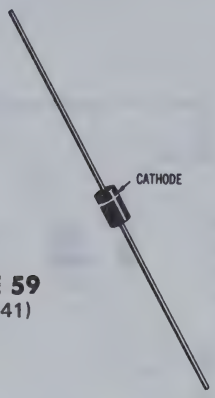
FIGURE 2 — DIODE UNDER TEST, WAVEFORM DIAGRAM



MR2271

For Specifications, See 1N4933 Data, Volume 1.

MR2272 (SILICON)



CASE 59
(DO-41)

Subminiature axial-lead silicon rectifier designed for video power-supply applications in low-voltage television receivers where video supply-voltage is obtained from horizontal deflection system.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	400	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	280	Volts
Average Rectified Forward Current (Sine wave operation) (75°C Ambient) (100°C Ambient)	I_O	 1.0 0.75	Amp
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	10	Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	$I_{FM(surge)}$	30 (for 1/2 cycle) @ 60 Hz	Amp
Juction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

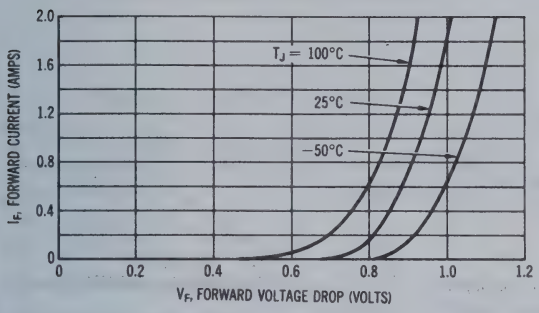
Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

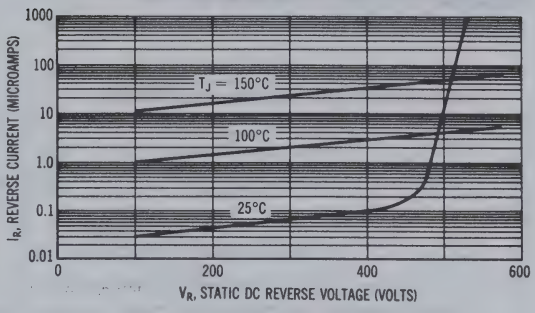
Characteristics	Symbol	Value	Unit
Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C)	V_F	1.1	Volts
Maximum Full Cycle Average Forward Voltage Drop (I_O = 0.75 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier, 60 Hz)	$V_{F(AV)}$	0.5	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C)	I_R	0.01	mA
Maximum Reverse Recovery Time (I_{RR} = 0.5 Amp)	t_{rr}	1.5	μs
Rectification Efficiency (Typical)	RE	55	%

MR2272 (continued)

TYPICAL FORWARD CHARACTERISTICS

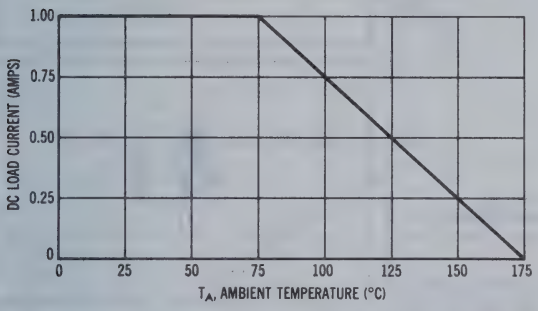


TYPICAL REVERSE CHARACTERISTICS

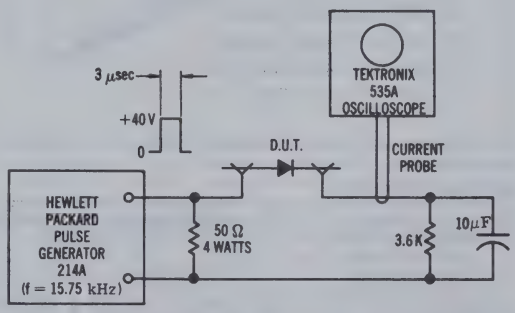


MAXIMUM ALLOWABLE DC OUTPUT

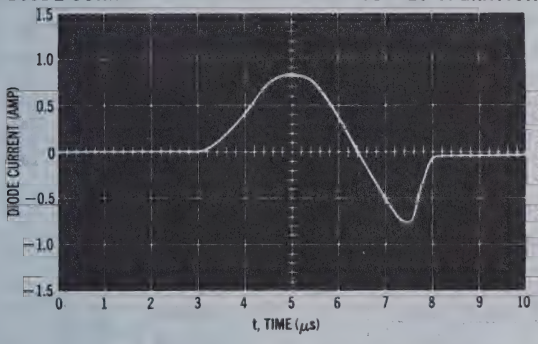
(Sine Wave Operation, Resistive or Inductive Load)



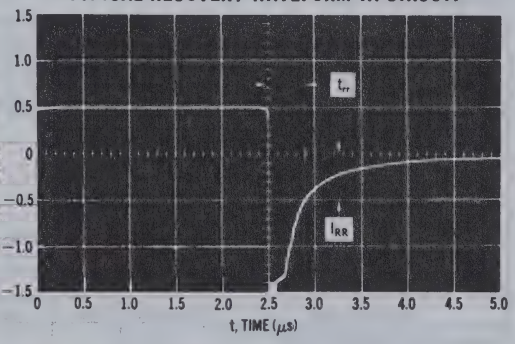
RECOVERY TIME TEST CIRCUIT



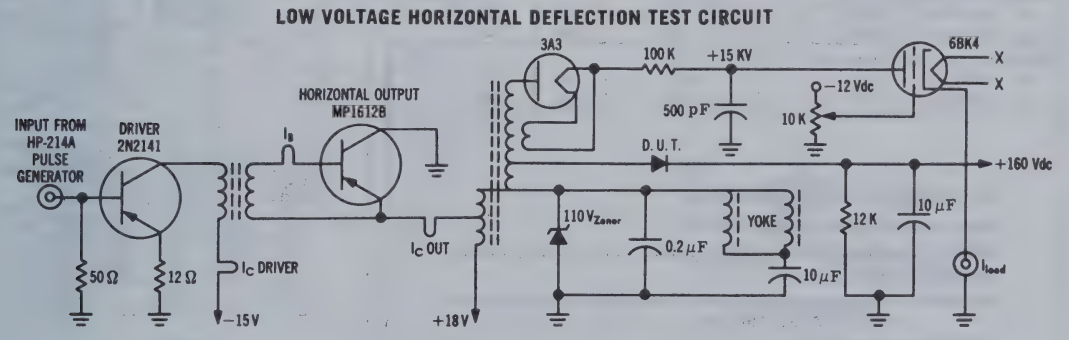
DIODE CURRENT WAVEFORM IN VIDEO SUPPLY OPERATION



TYPICAL RECOVERY WAVEFORM IN CIRCUIT



LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MR2273 (SILICON)

For Specifications, See MR2266 Data.

MR5005, MR5010, MR5020 (SILICON)
MR5030, MR5040

INDUSTRIAL PRESSFIT SILICON POWER RECTIFIERS

. . . designed for use in all medium-current applications or for higher current industrial alternators and chassis mounted power supply rectifiers.

- 50 Amp @ T_C = 150°C
- 600 Amp Surge Capability
- Reverse Polarity Available
- Rugged Construction

SILICON POWER RECTIFIERS

50-400 VOLTS
50 AMPERE



MAXIMUM RATINGS

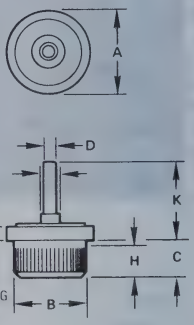
Rating	Symbol	MR5005	MR5010	MR5020	MR5030	MR5040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	400	450	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 150°C	I_O	← 50 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 600 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +195 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (i_F = 157 Amp, T_J = 25°C) (i_F = 50 Amp, T_J = 25°C)	v_F	 – –	 1.10 0.95	 1.18 1.00	Volts
Reverse Current (rated dc voltage) (T_C = 25°C) (T_C = 150°C)	I_R	 – –	 0.05 1.0	 0.2 2.0	mA



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.49	16.26	0.610	0.640
B	12.73	12.83	0.501	0.505
C	5.08	6.35	0.200	0.250
D	2.46	2.62	0.097	0.103
F	2.03	4.83	0.080	0.190
H	5.08	6.35	0.200	0.250
J	–	3.56	–	0.140
K	–	15.24	–	0.600

CASE 043-04

MECHANICAL CHARACTERISTICS

CASE: Welded hermetically sealed construction

FINISH: All external surfaces corrosion resistant, terminal readily solerable

WEIGHT: 9 grams (approx.)

POLARITY: Cathode connected to case (reverse polarity available denoted by Suffix R, i.e.: MR5030R)

MOUNTING POSITION: Any

FIGURE 1 – CURRENT DERATING

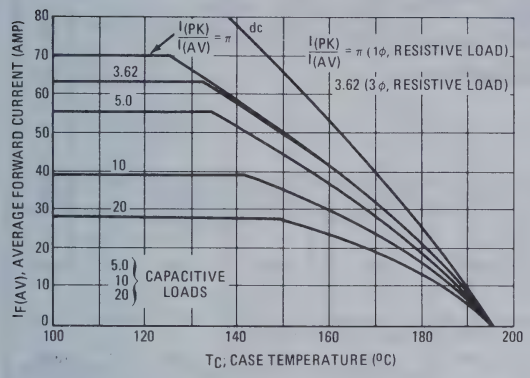


FIGURE 2 – FORWARD POWER DISSIPATION

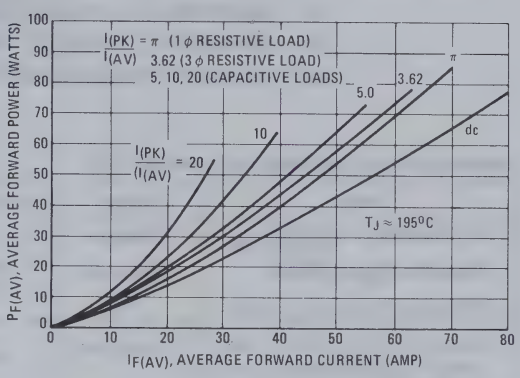


FIGURE 3 – MAXIMUM FORWARD VOLTAGE

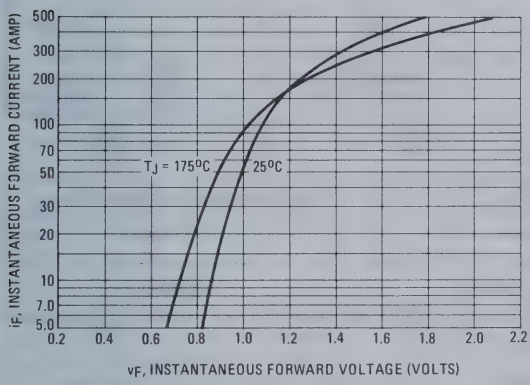


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CAPABILITY

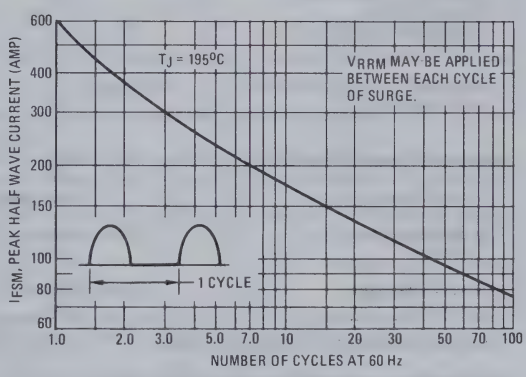
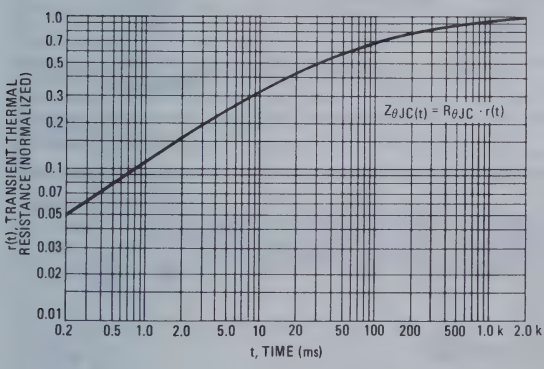
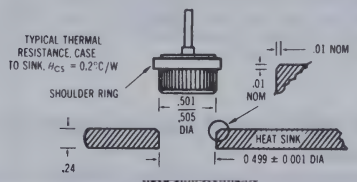


FIGURE 5 – THERMAL RESPONSE



Recommended procedures for mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to provide a guide into the hole and prevent shearing off the knurled side of the rectifier.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a thermal lubricant such as D.C. 340 will be of considerable aid.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

MRA130 (SILICON)
thru
MRA134

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA130 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA130	MRA131	MRA132	MRA133	MRA134	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	150					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	3000 for 1/2 cycle 1800 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	300 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, T_C = 150°C	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, T_C = 150°C	$I_{R(AV)}$	20	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, T_C = 25°C	I_R	1.5	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

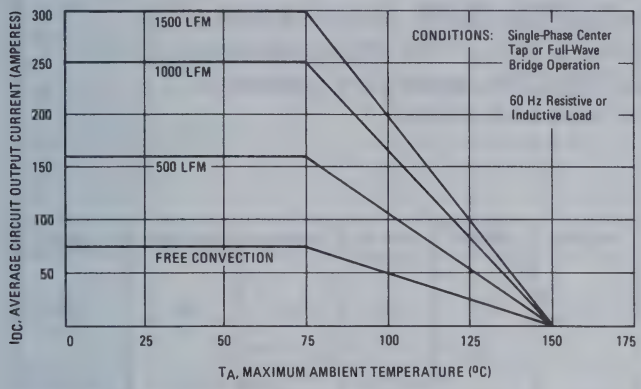
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA131R. (See Figure 2.)

MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA132B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

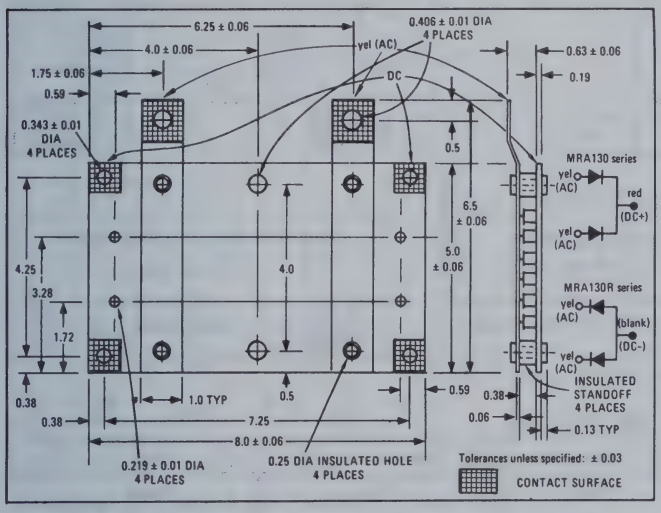
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

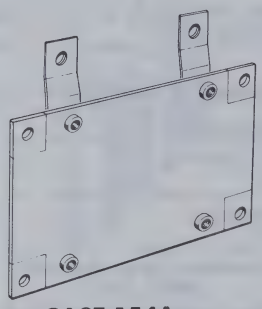




"C" CIRCUIT FOR SINGLE-PHASE OPERATION

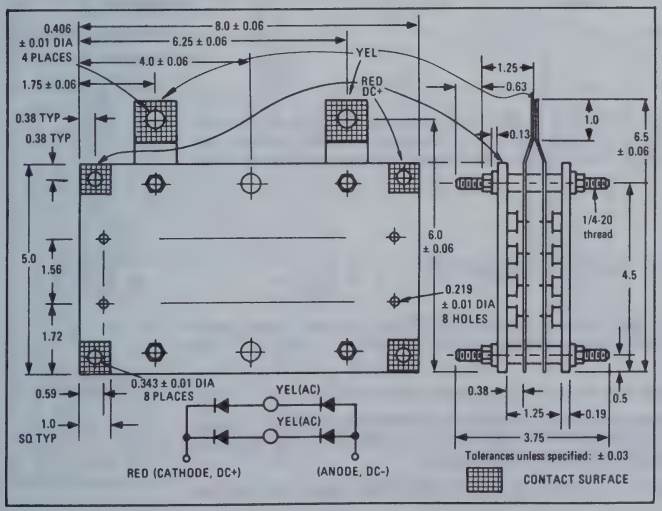
FIGURE 2 – MRA130 ("C" CIRCUIT)

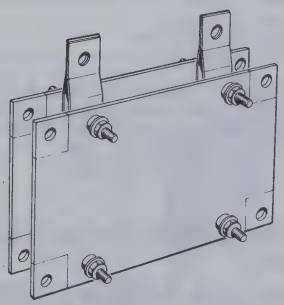




CASE 154A

FIGURE 3 – MRA130B (BRIDGE CIRCUIT)





CASE 155A

MRA160 (SILICON)
thru
MRA164

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA160 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA160	MRA161	MRA162	MRA163	MRA164	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, $T_C = 150^oC$)	I_o	300					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	6000 for 1/2 cycle 3600 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	600 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies One Each Polarity	600 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e.,MRA161R. (See Figure 2.)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e.,MRA162B. The bridges are composed of one common cathode and one common anode assembly.(See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

FIGURE 1 – MAXIMUM CIRCUIT RATINGS

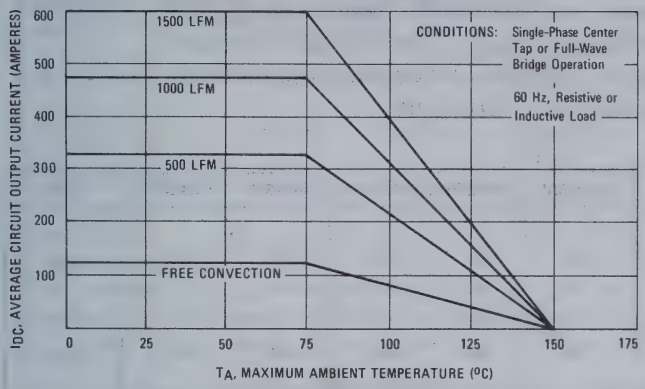


FIGURE 2 – MRA160 ("C" CIRCUIT)

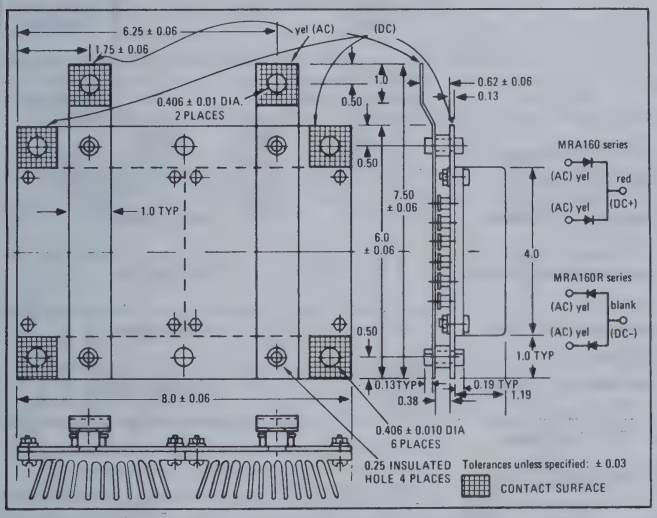
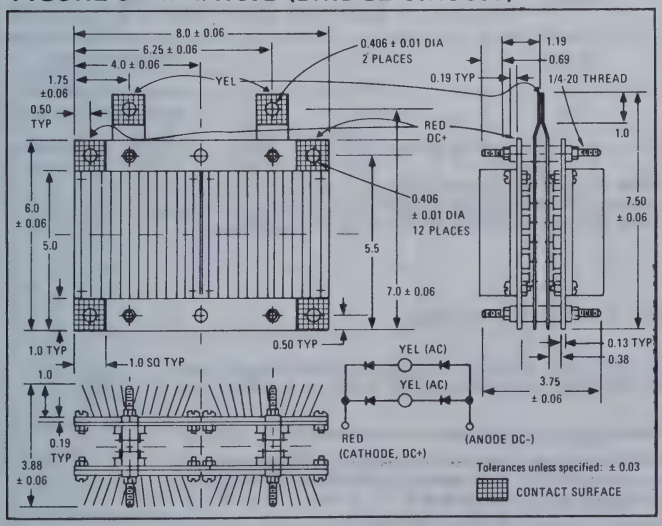
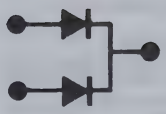
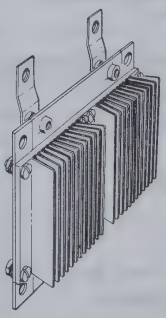


FIGURE 3 – MRA160B (BRIDGE CIRCUIT)

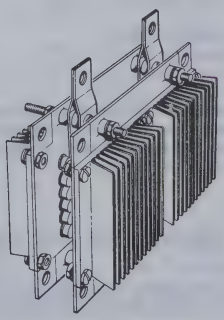




"C" CIRCUIT FOR SINGLE-PHASE OPERATION



CASE 156A



CASE 157A

MRA330 (SILICON)
thru
MRA334

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA330 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA330	MRA331	MRA332	MRA333	MRA334	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, $T_C = 150^oC$)	$I_{F(AV)}$	100					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	2000 for 1/2 cycle 1200 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly, Either Polarity	300 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	400 Amperes
Six-Phase with Interphase, 3Φ Double WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	600 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	15	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	1.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

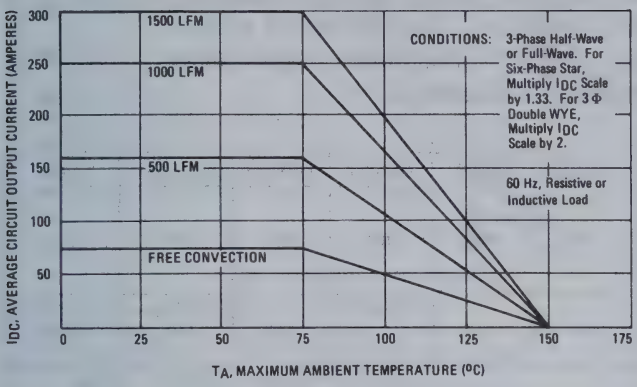
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA331R. (See Figure 2.)

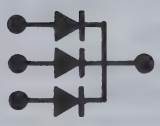
MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA332B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

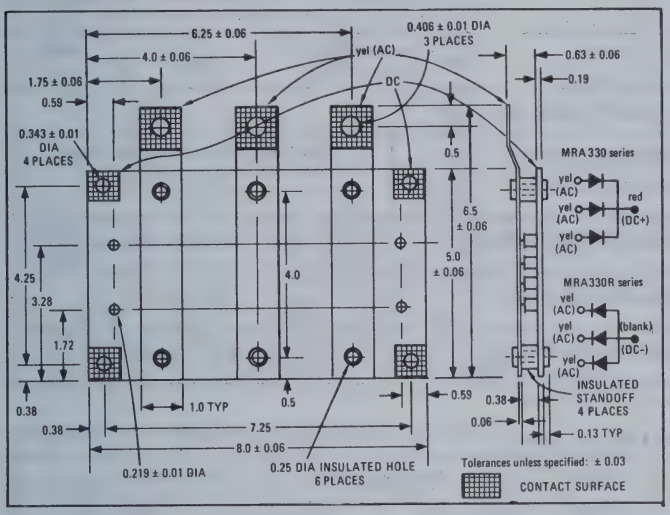
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

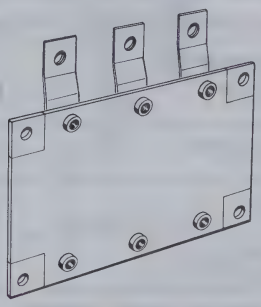




"Y" CIRCUIT
FOR POLYPHASE OPERATION

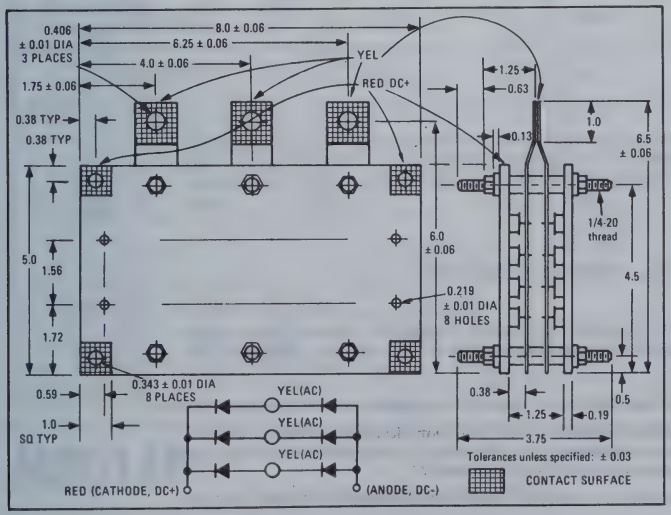
FIGURE 2 – MRA330 ("Y" CIRCUIT)

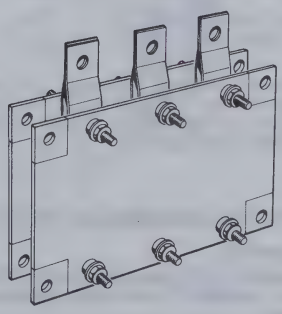




CASE 154

FIGURE 3 – MRA330B (BRIDGE CIRCUIT)





CASE 155

MRA360 (SILICON)
thru
MRA364

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA360 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA360	MRA361	MRA362	MRA363	MRA364	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, $T_C = 150^oC$)	$I_{F(AV)}$	220					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	5000 for 1/2 cycle 3000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1).

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly Either Polarity	650 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	650 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	870 Amperes
Six-Phase with Interphase, 3ΦDouble WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	1300 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

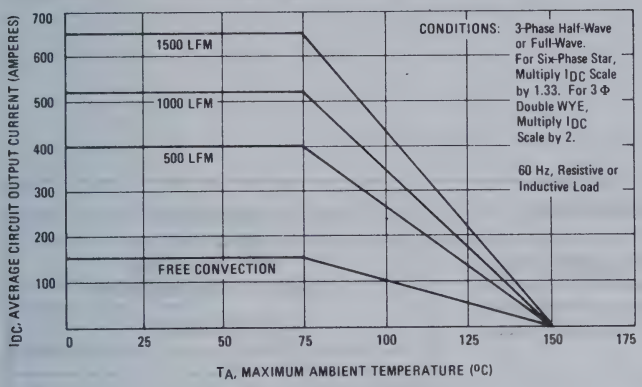
POLARITY:
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA361R. (See Figure 2)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA362B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

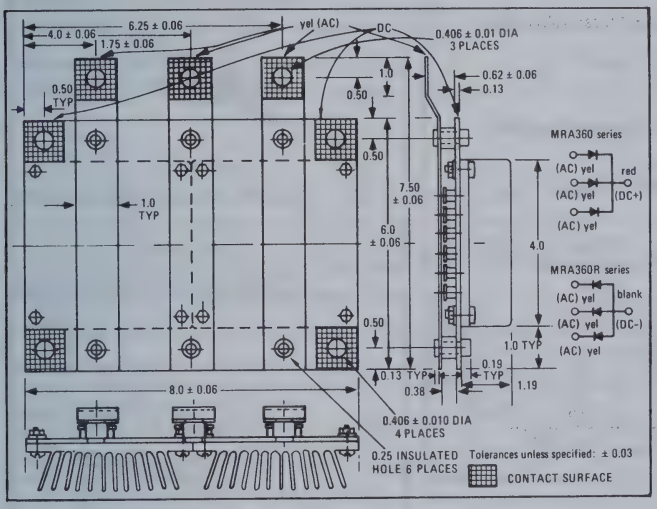
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

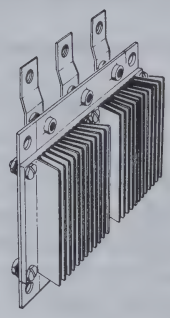




"Y" CIRCUIT
FOR POLYPHASE OPERATION

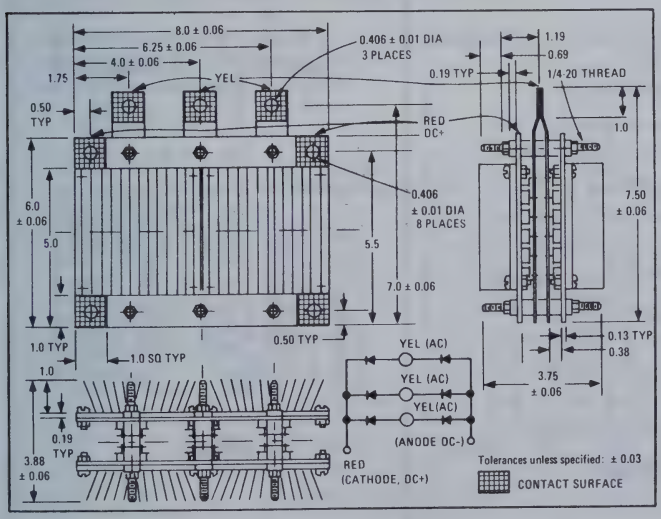
FIGURE 2 – MRA360 ("Y" CIRCUIT)

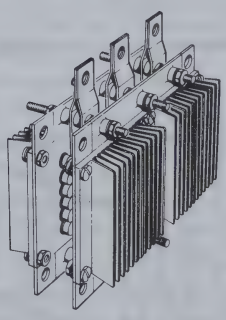




CASE 156

FIGURE 3 – MRA360B (BRIDGE CIRCUIT)





CASE 157

MRD14B

For Specifications see 2N5777.

MRD150 (SILICON)

PLASTIC NPN SILICON PHOTO TRANSISTORS

. . . designed for application in punched card and tape readers, pattern and character recognition equipment, shaft encoders, industrial inspection processing and control, counters, sorters, switching and logic circuits, or any design requiring radiation sensitivity, stable characteristics and high-density mounting.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Small Size for High-Density Mounting
- High Light Current Sensitivity (0.20 mA) for Design Flexibility
- Annular♦ Passivated Structure for Stability and Reliability

40 VOLT
MICRO-T
NPN SILICON
PHOTO TRANSISTOR

50 MILLIWATTS



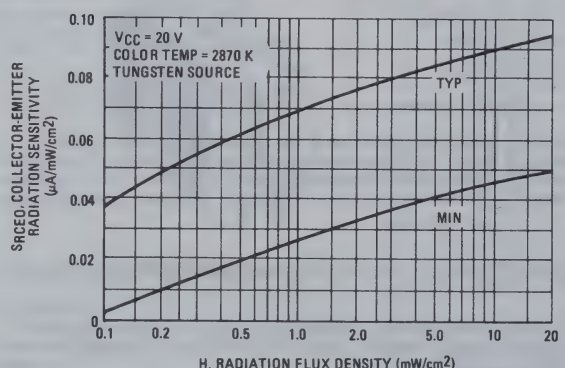
CASE 173

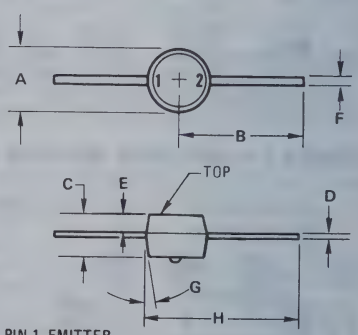
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	50 0.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J(1),T_{stg}	-40 to +100	°C

(1) Heat Sink should be applied to leads during soldering to prevent Case Temperature from exceeding 85°C.

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





PIN 1. EMITTER
2. COLLECTOR

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.078	0.092	1.98	2.34
B	0.160		4.06	
C	0.048	0.058	1.22	1.47
D	0.004	0.006	0.102	0.152
E	0.020	0.030	0.508	0.762
F	0.010	0.016	0.254	0.406
G	30	70	30	70
H	0.213 REF		5.41 REF	

CASE 173

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Dark Current (V_{CC} = 20 V; Base Open) (Note 2) T_A = 25°C T_A = 85°C	–	I_{CEO}	– –	– 5.0	0.10 –	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Base Open; Note 2)	–	BV_{CEO}	40	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Base Open; Note 2)	–	BV_{ECO}	6.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V; R_L = 100 ohms; Base Open) (Note 1)	1	S_{RCEO}	0.20	0.45	–	mA/mW/cm^2
Photo Current Rise Time (Note 3)	2 and 3	t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	–	–	4.0	μs
Wavelength of Maximum Sensitivity	9	$\lambda_{s(typ)}$	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated response time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ = 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 2 and Figure 3).

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

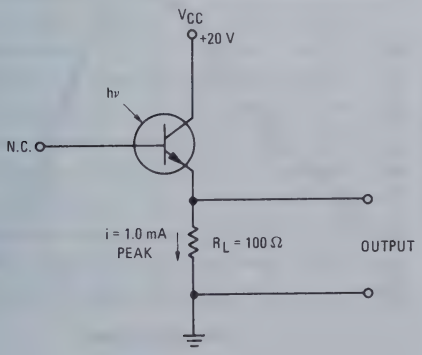
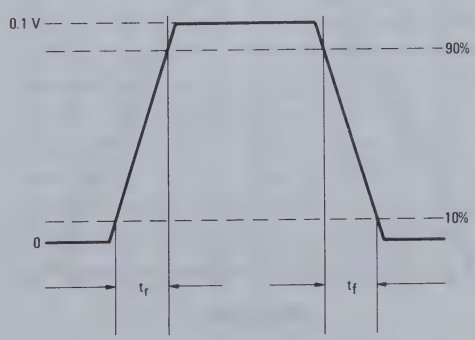


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – COLLECTOR-EMITTER CHARACTERISTICS

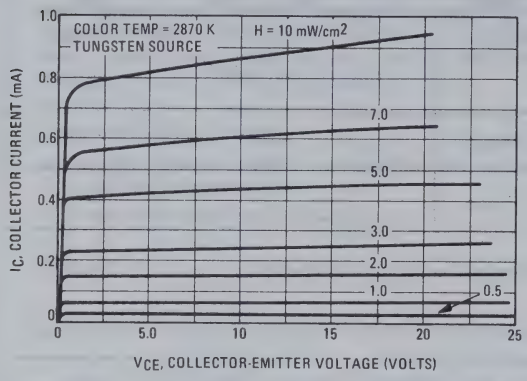


FIGURE 5 – COLLECTOR SATURATION CHARACTERISTICS

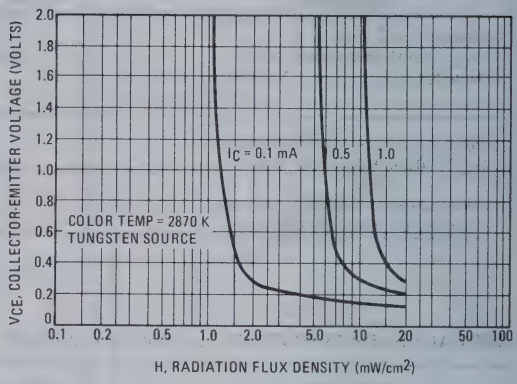


FIGURE 6 – DARK CURRENT versus TEMPERATURE

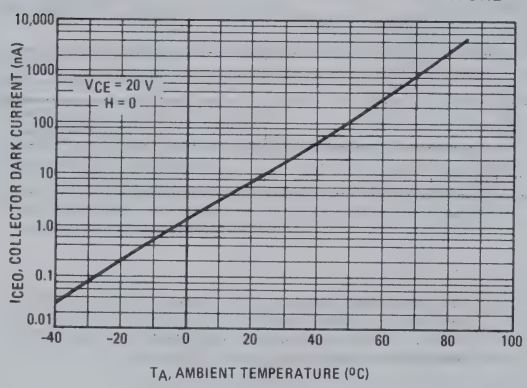


FIGURE 7 – DARK CURRENT versus VOLTAGE

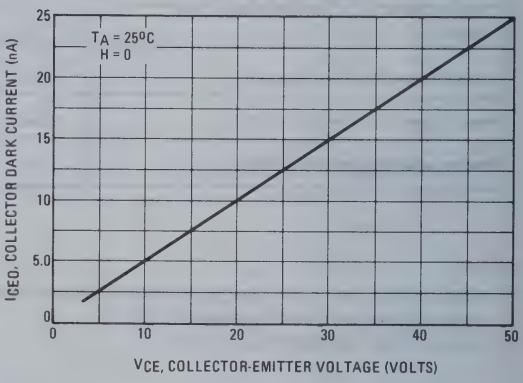
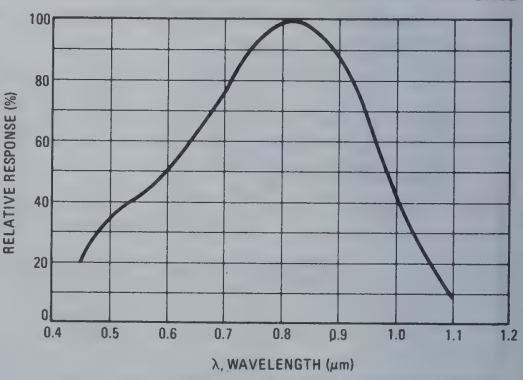


FIGURE 8 – ANGULAR RESPONSE



FIGURE 9 – CONSTANT ENERGY SPECTRAL RESPONSE



OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CBO} Collector-Base Breakdown Voltage — The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature. (Emitter open and $H \approx 0$)

BV_{CEO} Collector-Emitter Breakdown Voltage — The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{ECO} Emitter-Collector Breakdown Voltage — The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] — The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] — The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current — The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

T_A Ambient Temperature

t_f Photo Current Fall Time — The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)

T_J Junction Temperature

t_r Photo Current Rise Time — The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)

T_{stg} Storage Temperature

V_{CBO} Collector-Base Voltage — The maximum allowable value of the collector-base voltage which can be applied to the device at the rated temperature. (Base open)

V_{CEO} Collector-Emitter Voltage — The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage — The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

$\lambda_S(\mu m)$ Wavelength of maximum sensitivity in micrometers.

MRD300 (SILICON)
MRD310

NPN SILICON HIGH SENSITIVITY PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wider Application
- Minimum Light Current 4 mA at H = 5 mV/cm^2 (MRD 300)
- External Base for Added Control
- Annular Passivated Structure for Stability and Reliability

50 VOLT
PHOTO TRANSISTOR
NPN SILICON

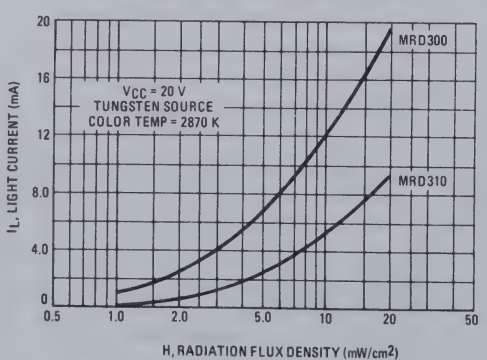
250 MILLIWATTS

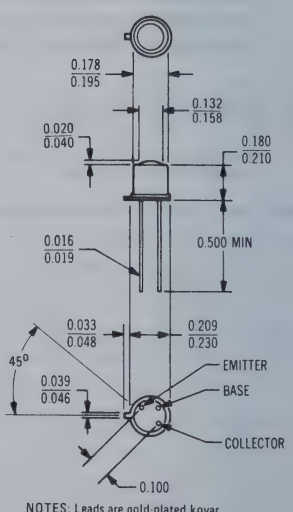


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CBO}	80	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.43	mW mW/°C
Operating Junction and Storage Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 – LIGHT CURRENT versus IRRADIANCE





NOTES: Leads are gold-plated kovar
Collector internally connected to case
Package weight ≈ 0.45 grams

CASE 82
TO-18

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, H≈0) T_A = 25°C T_A = 100°C	I_{CEO}	– –	– 4.0	25 –	na μA
Collector-Base Breakdown Voltage (I_C = 100 μA)	BV_{CBO}	80	–	–	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	50	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	7.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Device Type	Symbol	Min	Typ	Max	Unit
Light Current (V_{CC} = 20 V, R_L = 100 ohms) Note 1	MRD300 MRD310	I_L	4.0 1.0	7.5 2.5	– –	mA
Light Current (V_{CC} = 20 V, R_L = 100 ohms) Note 2	MRD300 MRD310	I_L	– –	2.5 0.8	– –	mA
Photo Current Rise Time (Note 3) (R_L = 100 ohms I_L = 1.0 mA peak)		t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3) (R_L = 100 ohms I_L = 1.0 mA peak)		t_f	–	–	4.0	μs

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Radiation flux density (H) equal to 0.5 mW/cm^2 (pulsed) from a GaAs (gallium-arsenide) source at λ≈0.9 μm.
3. For unsaturated response time measurements, radiation is provided by pulsed GaAs (gallium-arsenide) light-emitting diode (λ ≈ 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 6) I_L = 1.0 mA peak.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER SATURATION CHARACTERISTIC

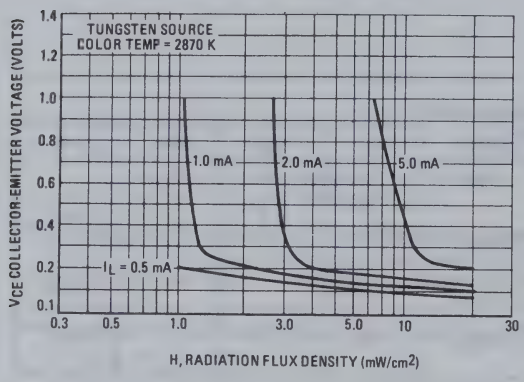


FIGURE 3 – NORMALIZED LIGHT CURRENT versus TEMPERATURE

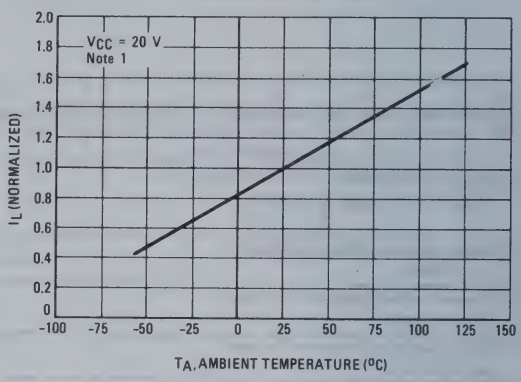


FIGURE 4 – RISE TIME versus LIGHT CURRENT

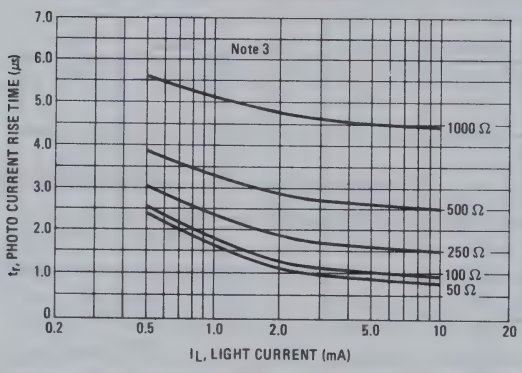


FIGURE 5 – FALL TIME versus LIGHT CURRENT

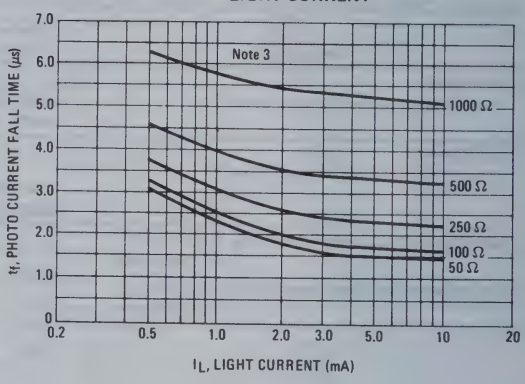
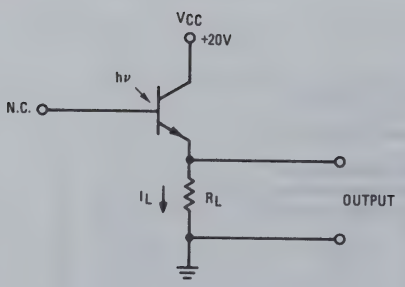


FIGURE 6 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM



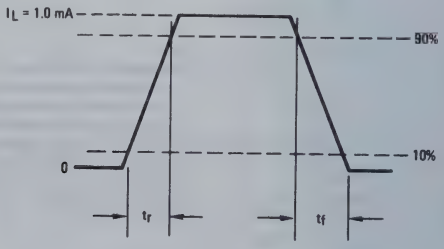


FIGURE 7 – DARK CURRENT versus TEMPERATURE

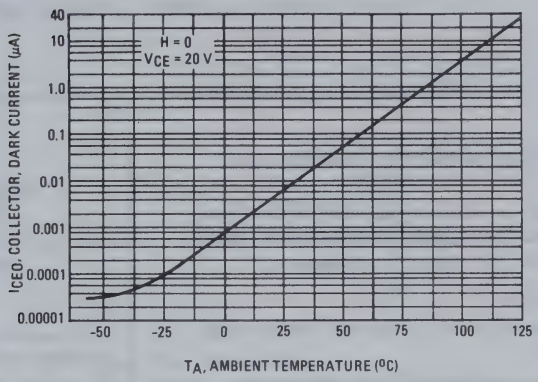


FIGURE 8 – CONSTANT ENERGY SPECTRAL RESPONSE

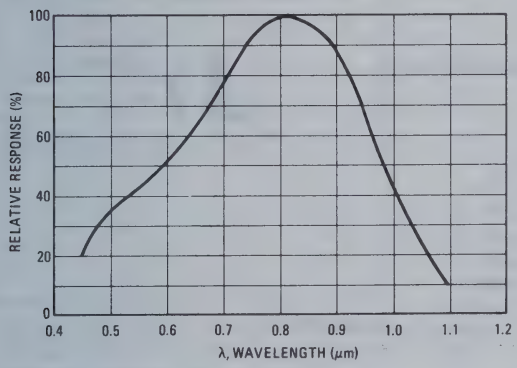
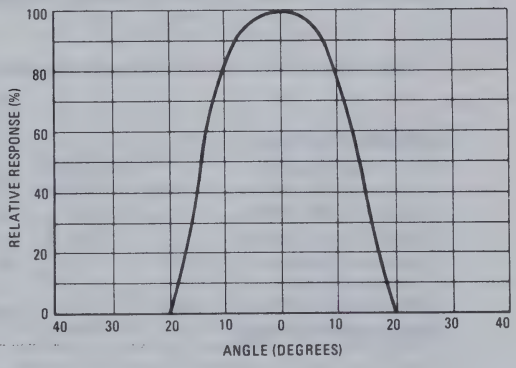


FIGURE 9 – ANGULAR RESPONSE



MRD450 (SILICON)

PLASTIC NPN SILICON PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Minimum Sensitivity (0.2 mA/mW/cm^2) for Design Flexibility
- Unique Molded Lens for High, Uniform Sensitivity
- Annular Passivated Structure for Stability and Reliability

40 VOLT
PHOTO TRANSISTOR
NPN SILICON

100 MILLIWATTS

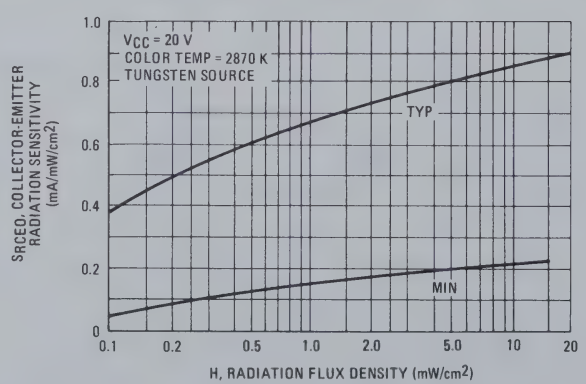


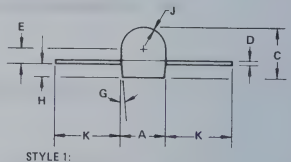
MAXIMUM RATINGS

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 1.3	mW mW/°C
Operating Junction Temperature Range Storage Temperature Range	T_J (1) T_{stg}	-40 to +85	°C

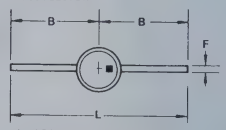
(1) Heat Sink should be applied to leads during soldering to prevent Case Temperature from exceeding 85°C.

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





STYLE 1:
PIN 1. EMITTER
2. COLLECTOR



Lead 2 indicated by square bonding pad on bottom of device.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.140	0.160	3.56	4.06
B	0.320		8.13	
C	0.180	0.210	4.57	5.33
D	0.009	0.011	0.229	0.279
E	0.070	0.080	1.78	2.03
F	0.013	0.019	0.330	0.483
G	30°	70°	30°	70°
H	0.040	0.050	1.02	1.27
J	0.075 TYP		1.91 TYP	
K	0.250		6.35	
L	0.640		16.26	

CASE 171

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, Note 2) T_A = 25°C T_A = 85°C	I_{CEO}	 – –	 – 5.0	 0.10 –	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Note 2)	BV_{CEO}	40	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Note 2)	BV_{ECO}	6.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	1	S_{RCEO}	0.2	0.8	–	mA/mW/cm^2
Photo Current Rise Time (Note 3)	2 and 3	t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	–	–	4.0	μs
Wavelength of Maximum Sensitivity	9	λ_s	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated response time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ ≈0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 2 and Figure 3).

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

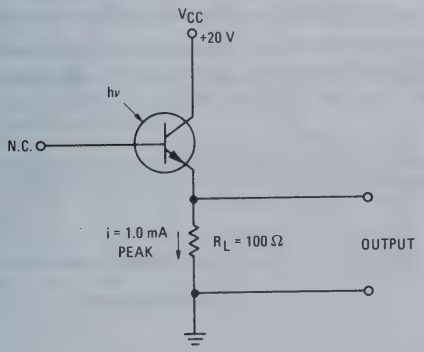
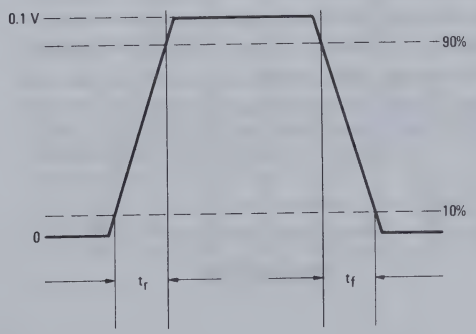


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – COLLECTOR-EMITTER CHARACTERISTICS

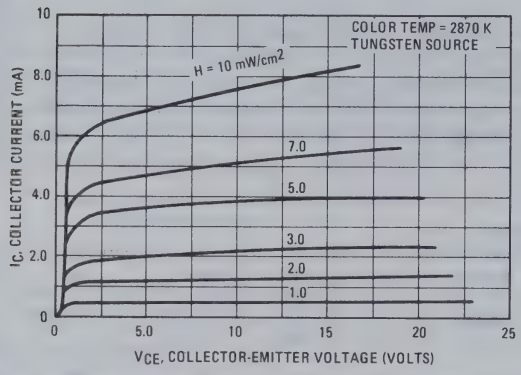


FIGURE 5 – COLLECTOR SATURATION CHARACTERISTICS

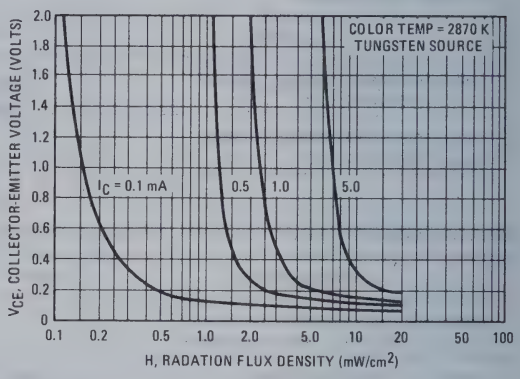


FIGURE 6 – DARK CURRENT versus TEMPERATURE

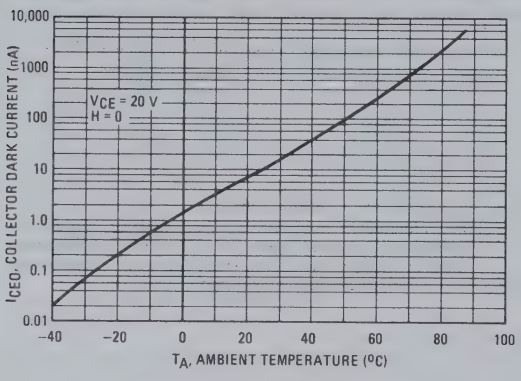


FIGURE 7 – DARK CURRENT versus VOLTAGE

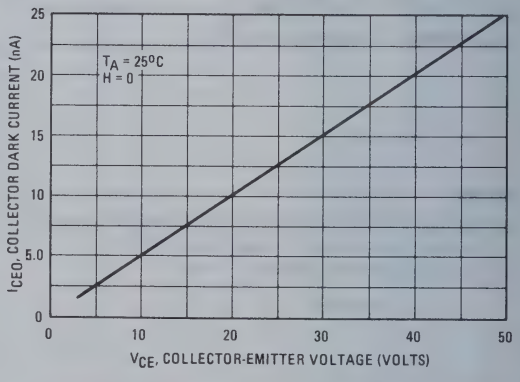
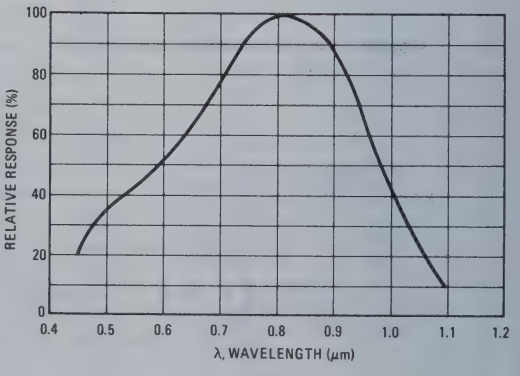


FIGURE 8 – ANGULAR RESPONSE



FIGURE 9 – CONSTANT ENERGY SPECTRAL RESPONSE



MRD450
OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and H ≈0)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and H ≈ 0)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, (H ≈ 0), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micro meters.

MOTOROLA CUSTOM OPTOELECTRONIC ARRAYS

Motorola optoelectronic devices are also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying Motorola optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or your Motorola representative will assist in developing specifications for your special application.

MRD500 (SILICON)
MRD510

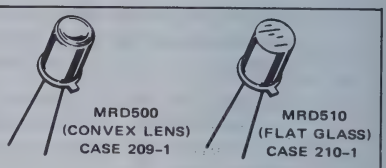
PIN SILICON PHOTO DIODE

. . . designed for application in laser detection, light demodulation, detection of visible and near infrared light-emitting diodes, shaft or position encoders, switching and logic circuits, or any design requiring radiation sensitivity, ultra high-speed, and stable characteristics.

- Ultra Fast Response – (<1.0 ns Typ)
- High Sensitivity – MRD500 (1.2 μA/mW/cm^2 Min) MRD510 (0.3 μA/mW/cm^2 Min)
- Available With Convex Lens (MRD500) or Flat Glass (MRD510) for Design Flexibility
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wide Application
- Annular Passivated Structure for Stability and Reliability

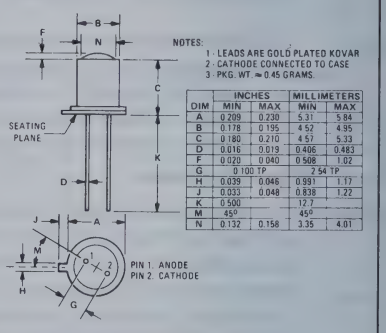
100 VOLT
PHOTO DIODE
PIN SILICON

100 MILLIWATTS



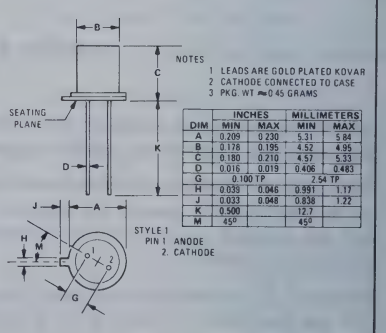
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 0.57	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	5.33
D	0.016	0.019	0.406	0.483
F	0.020	0.040	0.508	1.02
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.7	
M	45°		45°	
N	0.132	0.158	3.35	4.01

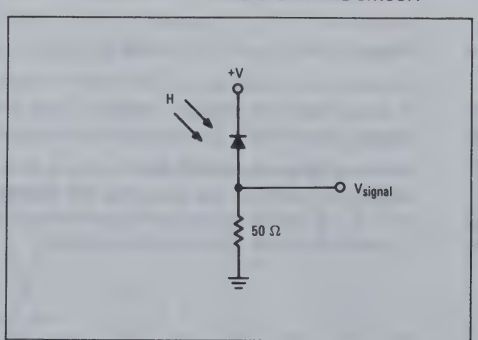
CASE 209-1



DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	5.33
D	0.016	0.019	0.406	0.483
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.7	
M	45°		45°	

CASE 210-1

FIGURE 1 – TYPICAL OPERATING CIRCUIT



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Dark Current (V_R = 20 V, R_L = 1.0 megohm; Note 2)		I_D				nA
T_A = 25°C	4 and 5		–	–	2.0	
T_A = 100°C			–	14	–	
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	100	200	–	Volts
Forward Voltage (I_F = 50 mA)	–	V_F	–	–	1.1	Volts
Series Resistance (I_F = 50 mA)	–	R_s	–	–	10	ohms
Total Capacitance (V_R = 20 V; f = 1.0 MHz)	6	C_T	–	–	4	pF

OPTICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Radiation Sensitivity (V_R = 20 V, Note 1)			S_R				μA/mW/cm^2
	MRD500	2 and 3		1.2	1.8	–	
	MRD510			0.3	0.42	–	
Sensitivity at 0.8 μm (V_R = 20 V, Note 3)			$S(\lambda = 0.8\ \mu m)$				μA/mW/cm^2
	MRD500	–		–	6.6	–	
	MRD510	–			1.5	–	
Response Time (V_R = 20 V, R_L = 50 ohms)		–	$t_{(resp)}$		1.0		ns
		–					
Wavelength of Peak Spectral Response		7	λ_s	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. ($H \approx 0$).
3. Radiation Flux Density (H) equal to 0.5 mW/cm^2 at 0.8 μm.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD500

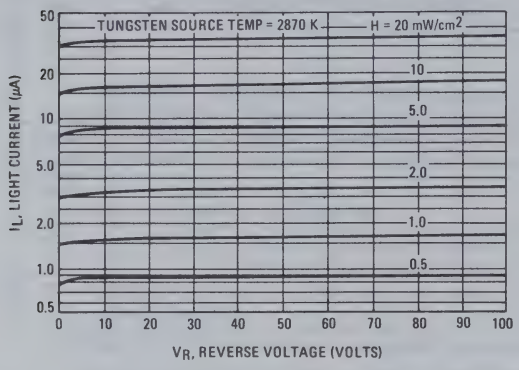


FIGURE 3 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD 510

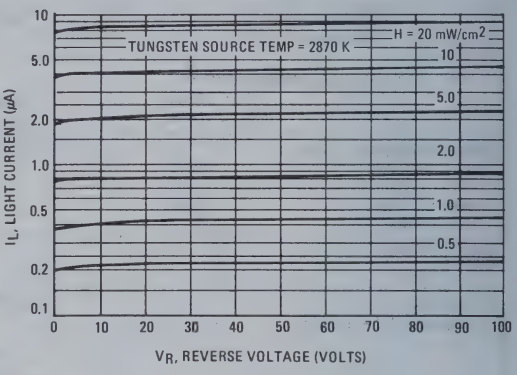


FIGURE 4 – DARK CURRENT versus TEMPERATURE

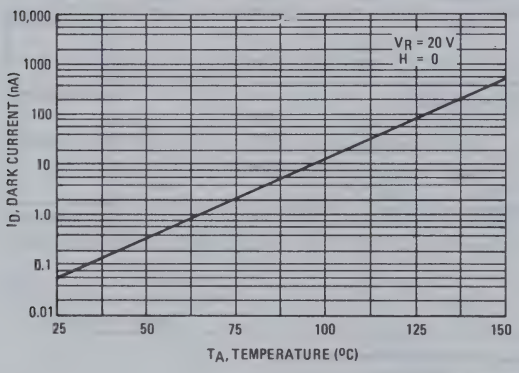


FIGURE 5 – DARK CURRENT versus REVERSE VOLTAGE

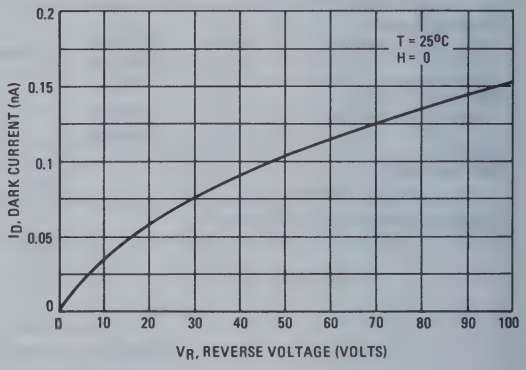


FIGURE 6 – CAPACITANCE versus VOLTAGE

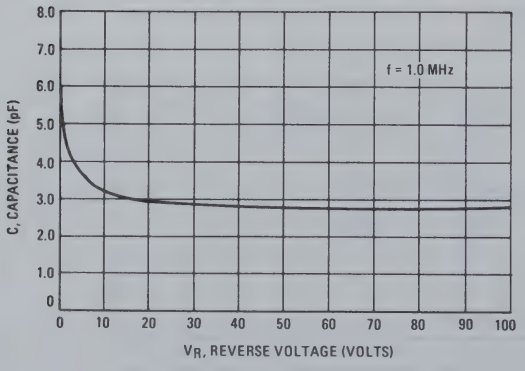
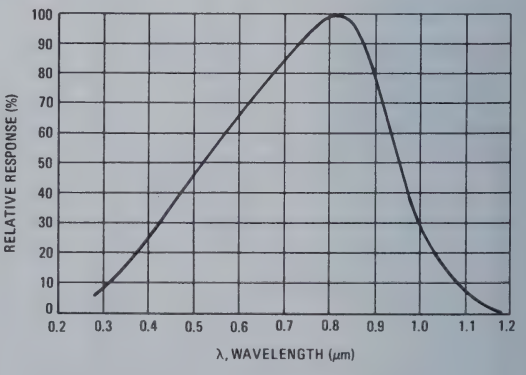


FIGURE 7 – RELATIVE SPECTRAL RESPONSE



MRD500 AND MRD510
OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_R Reverse Breakdown Voltage – The minimum dc reverse breakdown voltage at stated diode current and ambient temperature.

C_T Total Capacitance

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_D Dark Current – The maximum reverse leakage current through the device measured under dark conditions, ($H \approx 0$), with a stated reverse voltage, load resistance, and ambient temperature.

P_D Power Dissipation

R_S Series Resistance – The maximum dynamic series resistance measured at stated forward current and ambient temperature.

S_R Radiation Sensitivity ($\mu A/mW/cm^2$) – The ratio of photo-induced current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), reverse voltage, load resistance, and ambient temperature.

T_A Ambient Temperature

T_J Junction Temperature

T_{stg} Storage Temperature

V_F Forward Voltage – The maximum forward voltage drop across the diode at stated diode current and ambient temperature.

V_R Reverse Voltage – The maximum allowable value of dc reverse voltage which can be applied to the device at the rated temperature.

$\lambda_s(\mu m)$ Wavelength of peak spectral response in micro meters.

OPTO DEVICES

AN-440 – THEORY AND CHARACTERISTICS OF PHOTO TRANSISTORS

A brief history of the photoelectric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the phototransistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.

AN-508 Applications of Phototransistors in Electro-Optic Systems

This note reviews phototransistor theory, characteristics and terminology, then discusses the design of electro-optic systems using device information and geometric considerations. It also includes several circuit designs that are suited to dc, low-frequency and high-frequency applications.

MRD601 (SILICON)
thru
MRD604

NPN SILICON PHOTO DETECTOR

. . . designed for application in card and tape readers, pattern and character recognition, and shaft encoders, or any design requiring radiation sensitivity, stable characteristics, and high-density mounting.

- Low Profile Lens Reduces Optical Cross-Talk
- Pill Package Designed for PC Board Insertion
- Wide Range of Output Currents
- Excellent Match to Tungsten and Gallium-Arsenide Sources
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wider Application
- Rugged Hermetic Package
- Annular Passivated Structure for Stability and Reliability

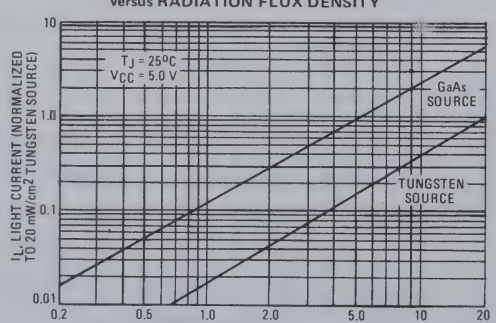
50 VOLT
NPN SILICON
PHOTO DETECTOR
50 MILLIWATTS

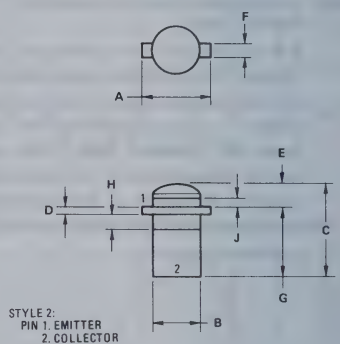


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	50 0.5	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Soldering Temperature		240°C for 3 minutes	

FIGURE 1 – NORMALIZED LIGHT CURRENT versus RADIATION FLUX DENSITY





STYLE 2:
PIN 1. EMITTER
2. COLLECTOR

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.083	0.093	2.110	2.360
B	0.058	0.062	1.470	1.570
C		0.125		3.180
D	0.003	0.007	0.076	0.178
E	0.023	0.029	0.584	0.737
F	0.018	0.022	0.457	0.559
G	0.082	0.094	2.080	2.390
H	0.014	0.020	0.356	0.508
J	0.008	0.012	0.203	0.305

CASE 81A-03

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 30 V, H = 0) T_A = 25°C	I_{CEO}	–	–	25	nA
T_A = 100°C		–	1.0	–	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA, H = 0)	BV_{CEO}	50	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA, H = 0)	BV_{ECO}	7.0	–	–	Volts

ELECTRO-OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Light Current (V_{CC} = 5.0 V, R_L = 100 ohms, H = 20 mW/cm²)	I_L				mA
MRD601		0.5	1.5	–	
MRD602		2.0	3.5	–	
MRD603		4.0	6.0	–	
MRD604		7.0	8.5	–	
(Note 1 – Figure 1)					
Light Current (V_{CC} = 5.0 V, R_L = 100 ohms, H = 0.5 mW/cm²)	I_L				mA
MRD601		–	0.08	–	
MRD602		–	0.18	–	
MRD603		–	0.30	–	
MRD604		–	0.45	–	
(Note 2 – Figure 1)					
Collector-Emitter Saturation Voltage (I_C = 0.5 mA, H = 20 mW/cm²) (Note 1 – Figure 2)	$V_{CE(sat)}$	–	0.13	–	Volts
Rise Time (V_{CC} = 30 V, I_L = 800 μA, R_L = 1000 ohms) (Note 3 – Figure 10)	t_r	–	1.5	–	μs
Fall Time	t_f	–	15	–	μs
Rise Time (V_{CC} = 30 V, I_L = 800 μA, R_L = 100 ohms) (Note 4 – Figure 10)	t_r	–	2.0	–	μs
Fall Time	t_f	–	2.8	–	μs

NOTES:

1. Radiation Flux Density (H) equal to 20 mW/cm² emitted from a tungsten source at a color temperature of 2870°K.
2. Radiation Flux Density (H) equal to 0.5 mW/cm² emitted from a GaAs (gallium-arsenide) source at λ≈900 nM.
3. For this response time measurement, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 μs (see Figure 10).
4. For this response time measurement, radiation is provided by a pulsed GaAs (gallium arsenide) light emitting diode (λ≈900 nM) with a pulse width equal to or greater than 10 μsec (see Figure 10), I_L = 800 μA.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE versus RADIATION FLUX DENSITY

FIGURE 2 – SATURATION CHARACTERISTICS WITH TUNGSTEN SOURCE

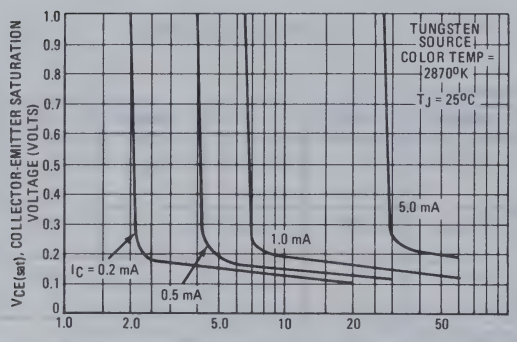
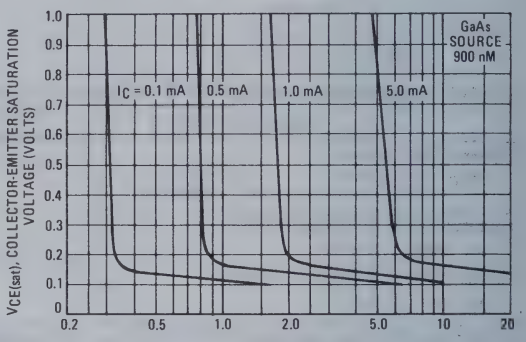


FIGURE 3 – SATURATION CHARACTERISTICS WITH GaAs SOURCE



COUPLING CHARACTERISTICS WITH GaAs SOURCE

FIGURE 4 – CONTINUOUS LIGHT CURRENT versus DISTANCE

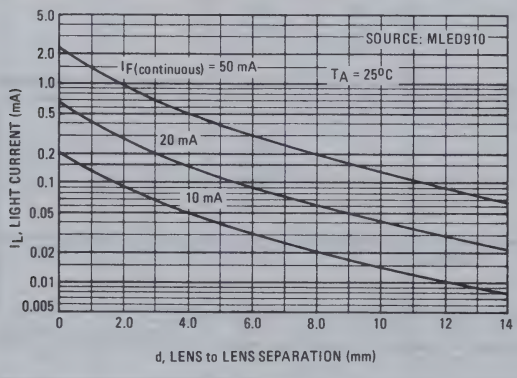


FIGURE 5 – PULSED LIGHT CURRENT versus DISTANCE

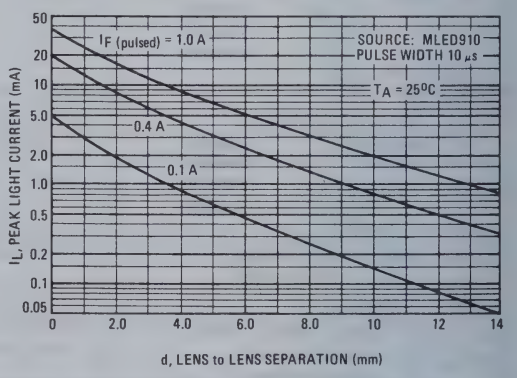


FIGURE 6 – DARK CURRENT versus TEMPERATURE

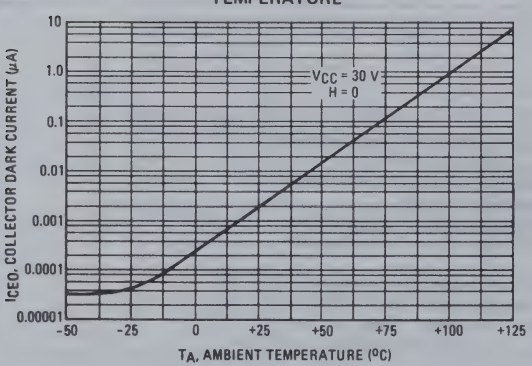


FIGURE 7 – NORMALIZED LIGHT CURRENT versus TEMPERATURE

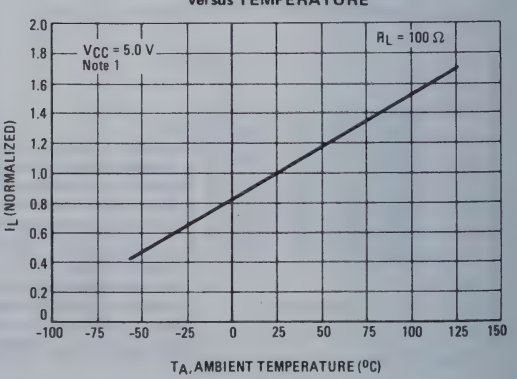


FIGURE 8 – RISE TIME versus LIGHT CURRENT

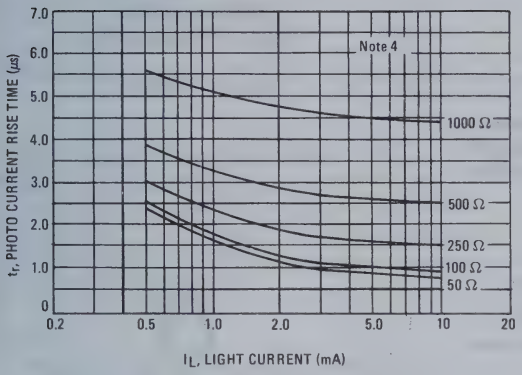


FIGURE 9 – FALL TIME versus LIGHT CURRENT

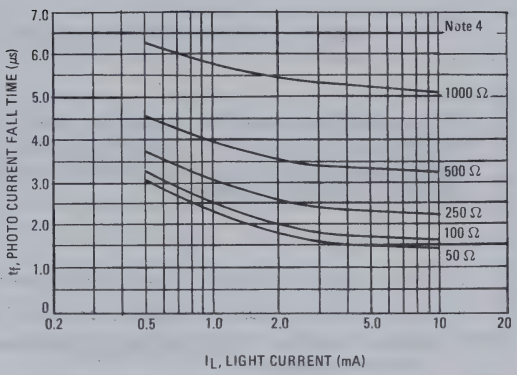
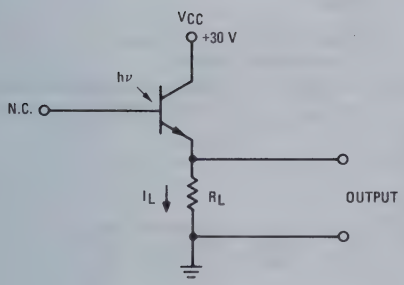


FIGURE 10 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM



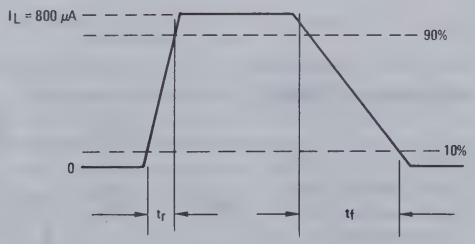


FIGURE 11 – ANGULAR RESPONSE

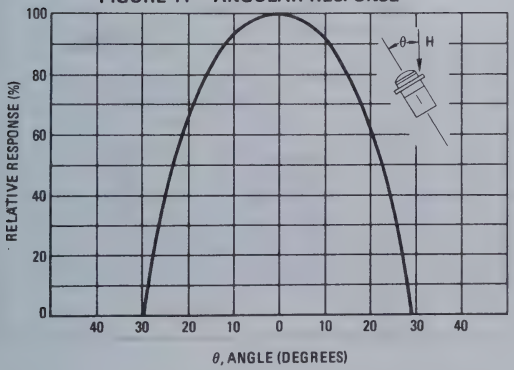
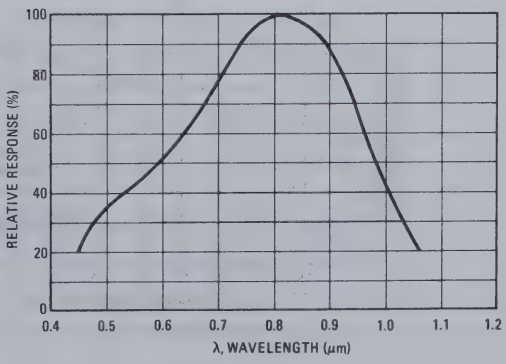


FIGURE 12 – CONSTANT ENERGY SPECTRAL RESPONSE



MRD810 (SILICON)

NPN SILICON PHOTO TRANSISTOR

. . . designed for application in card and tape readers, optical character recognition, shaft encoders, industrial inspection, processing and control, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Popular TO-18 Type Package for Easy Handling and Mounting
- Minimum Sensitivity (0.2 mA/mW/cm^2) for Design Flexibility
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wider Application
- Annular Passivated Structure for Stability and Reliability
- Flat Lens for Fiber Optic Coupling
- Precision Die Location for Minimum Optical Tolerances

35 VOLTS
NPN SILICON
PHOTO TRANSISTOR

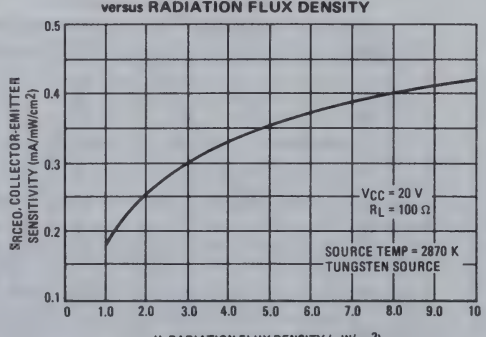
250 MILLIWATTS

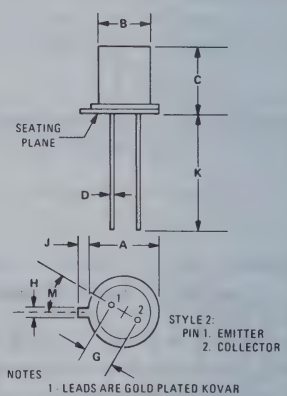


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Volts
Emitter-Collector Voltage	V_{ECO}	5.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.5	mW mW/°C
Operating Junction and Storage Temperature Range	T_J,T_{stg}	-55 to +125	°C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY versus RADIATION FLUX DENSITY





NOTES
1. LEADS ARE GOLD PLATED KOVAR
2. CATHODE CONNECTED TO CASE
3. PKG. WT. ≈ 0.45 GRAMS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	5.33
D	0.016	0.019	0.406	0.483
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.7	
M	45°		45°	

CASE 210 (2)

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 2) T_A = 25°C	I_{CEO}	–	–	0.050	μA
T_A = 100°C		–	10	–	
Collector-Emitter Breakdown Voltage (I_C = 100 μA, Note 2)	BV_{CEO}	35	50	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA, Note 2)	BV_{ECO}	5.0	8.0	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	S_{RCEO}	0.2	–	–	mA/mW/cm²
Photo Current Saturated Rise Time (Note 3)	$t_{r(sat)}$	–	2.0	–	μs
Photo Current Saturated Fall Time (Note 3)	$t_{f(sat)}$	–	25	–	μs
Photo Current Rise Time (Note 4)	t_r	–	–	5.0	μs
Photo Current Fall Time (Note 4)	t_f	–	–	6.0	μs

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm² emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 2).
4. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ≈0.9 μm) with a pulse width equal to or greater than 20 microseconds.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

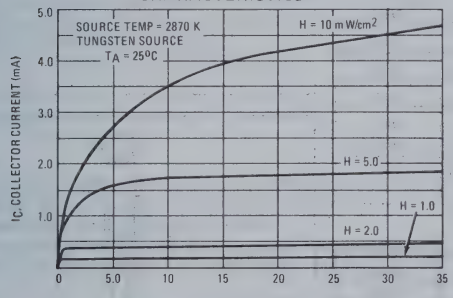


FIGURE 3 – COLLECTOR SATURATION CHARACTERISTICS

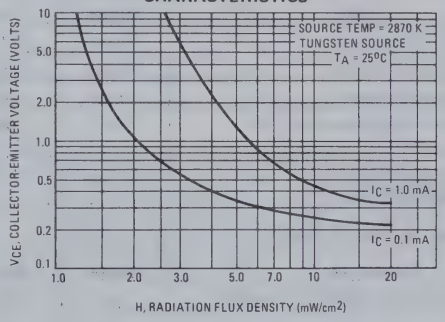


FIGURE 4 – DARK CURRENT versus TEMPERATURE

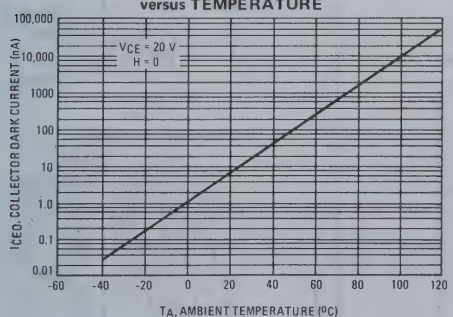
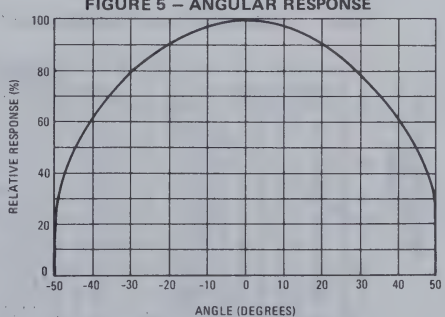


FIGURE 5 – ANGULAR RESPONSE



MRD3050 (SILICON)
thru
MRD3056

NPN SILICON PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Hermetic Package at Economy Prices
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wider Application
- Range of Radiation Sensitivities for Design Flexibility
- External Base for Added Control
- Annular Passivated Structure for Stability and Reliability

30 VOLT
NPN SILICON
PHOTO TRANSISTOR
400 MILLIWATTS



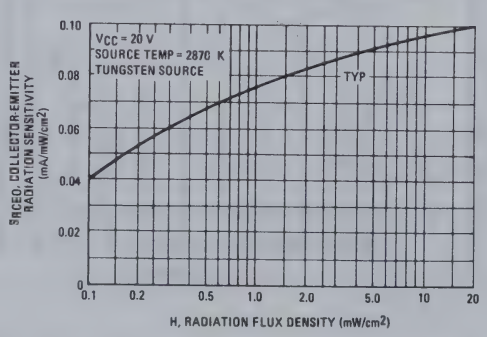
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

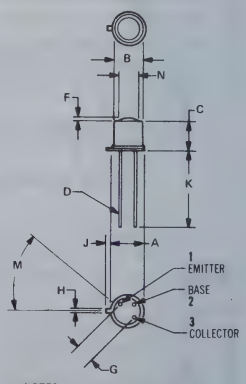
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	5.0	Volts
Collector-Base Voltage	V_{CBO}	40	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	438	°C/W

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





NOTES: Leads are gold-plated kovar
Collector internally connected to case
Package weight ≈ 0.45 grams

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.209	0.230	5.31	5.84
B	0.178	0.195	4.52	4.95
C	0.180	0.210	4.57	4.33
D	0.016	0.019	0.406	0.483
F	0.020	0.040	0.508	1.02
G	0.100 TP		2.54 TP	
H	0.039	0.046	0.991	1.17
J	0.033	0.048	0.838	1.22
K	0.500		12.70	
M	45°		45°	
N	0.132	0.158	3.35	4.01

CASE 82-01

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 1.0 Megohm, Note 2) T_A = 25°C	I_{CEO}	–	–	0.1	μA
T_A = 85°C		–	5.0	–	
Collector-Base Breakdown Voltage (I_C = 100 μA)	BV_{CBO}	40	–	–	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	30	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	5.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	MRD3050	1	S_{RCEO}	0.02	–	–	mA/mW/cm²
	MRD3051			0.04	–	–	
	MRD3052			0.02	–	0.08	
	MRD3053			0.05	–	0.2	
	MRD3054			0.125	–	0.5	
	MRD3055			0.3	–	–	
	MRD3056			0.4	–	–	
Photo Current Saturated Rise Time (Note 3)		4	$t_{r(sat)}$	–	1.0	–	μs
Photo Current Saturated Fall Time (Note 3)		4	$t_{f(sat)}$	–	10	–	μs
Photo Current Rise Time (Note 4)		4	t_r	–	2.0	–	μs
Photo Current Fall Time (Note 4)		4	t_f	–	3.5	–	μs
Wavelength of Maximum Sensitivity		–	λ_s	–	0.8	–	μm

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm² emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. ($H \approx 0$).
3. For saturated switching time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
4. For unsaturated switching time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ μm) with a pulse width equal to or greater than 10 microseconds (see Figure 4).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

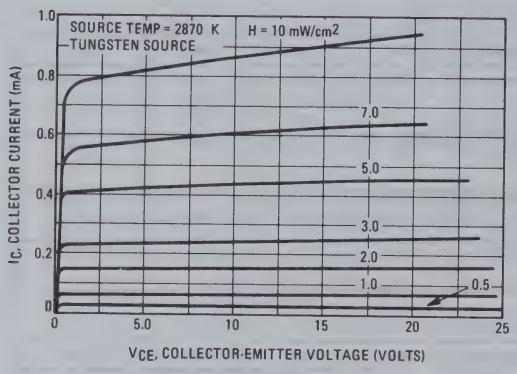


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

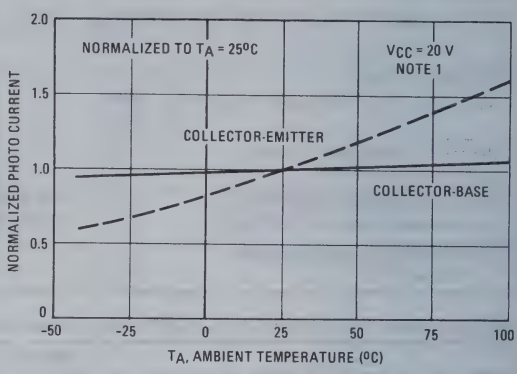
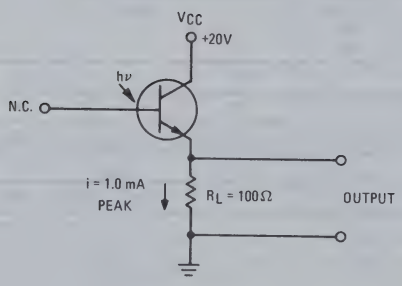


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM



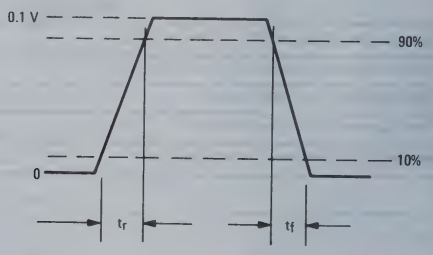
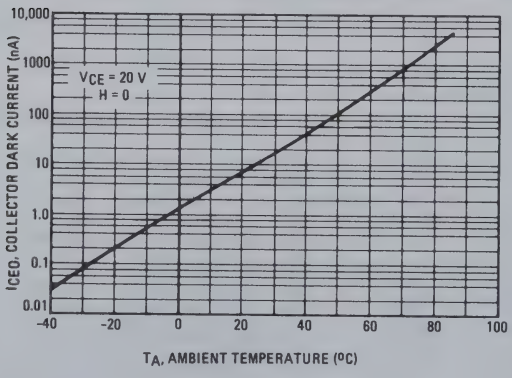


FIGURE 5 – DARK CURRENT versus TEMPERATURE



TYPICAL CIRCUIT APPLICATIONS

(Extracted from Motorola Applications Note AN-508, "Applications of Phototransistors in Electro-Optic Systems")

FIGURE 6 – STROBEFLASH SLAVE ADAPTER

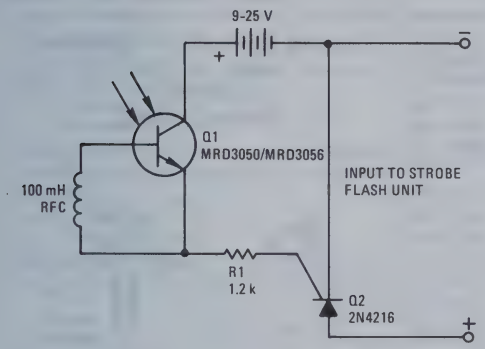


FIGURE 7 – LIGHT OPERATED SCR ALARM USING SENSITIVE-GATE SCR

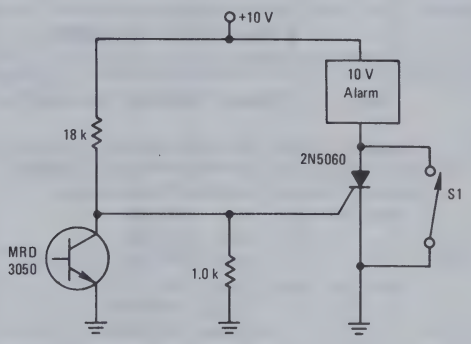
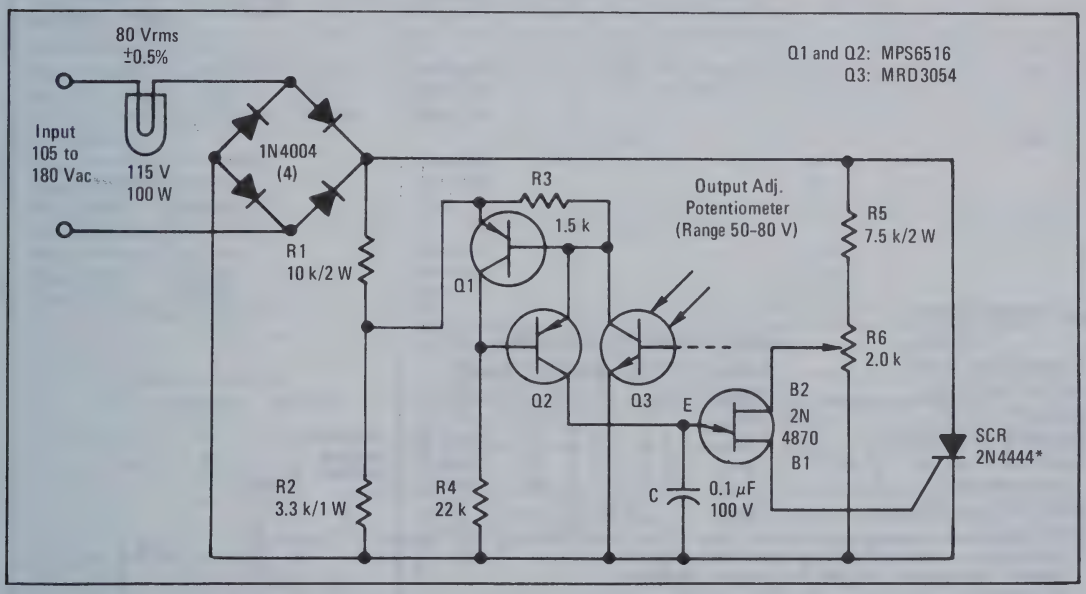


FIGURE 8 – CIRCUIT DIAGRAM OF VOLTAGE REGULATOR FOR PROJECTION LAMP.



*2N4444 to be used with a heat sink.

MRF207, MRF208, MRF209 (SILICON)

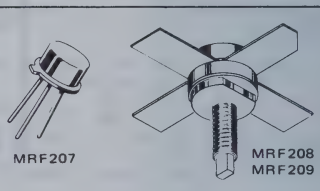
The RF Line

NPN SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt large-signal power amplifier applications in communications equipment operating at 220 MHz.

- Specified 12.5 Volt, 220 MHz Characteristics –
  Output Power = 1.0 W – MRF207
  10 W – MRF208
  25 W – MRF209
  Minimum Gain = 8.2 dB – MRF207
  10 dB – MRF208
  4.4 dB – MRF209
- Balanced-Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.

1.0, 10, 25 WATTS – 220 MHz
NPN SILICON
RF POWER
TRANSISTORS

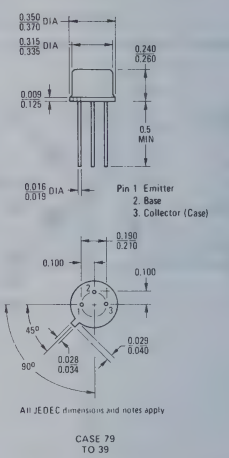


MAXIMUM RATINGS

Rating	Symbol	MRF207	MRF208	MRF209	Unit
Collector-Emitter Voltage	V_{CEO}	← 18 →			Vdc
Collector-Base Voltage	V_{CBO}	← 36 →			Vdc
Emitter-Base Voltage	V_{EBO}	← 4.0 →			Vdc
Collector Current – Continuous	I_C	0.4	2.0	4.0	Adc
Total Device Dissipation @ $T_C = 25^oC$(1)	P_D	3.5	37.5	50	Watts
Derate above 25^oC		20	214	286	$mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200			^oC
Stud Torque(2)	–	–	6.5		in. lb.

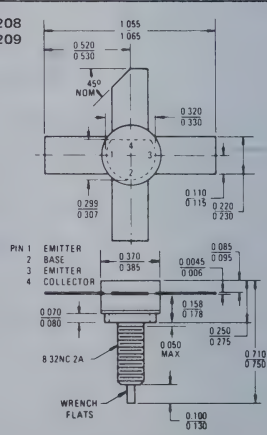
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.
(2) For Repeated Assembly use 5 in. lb.

MRF207



CASE 79
TO 39

MRF208
MRF209



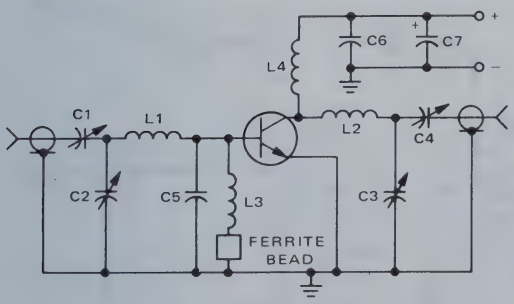
CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 5.0 mAdc, I_B = 0)	MRF207		18	–	–	
(I_C = 15 mAdc, I_B = 0)	MRF208		18	–	–	
(I_C = 20 mAdc, I_B = 0)	MRF209		18	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 2.0 mAdc, I_E = 0)	MRF207		36	–	–	
(I_C = 5.0 mAdc, I_E = 0)	MRF208		36	–	–	
(I_C = 10 mAdc, I_E = 0)	MRF209		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	MRF207		4.0	–	–	
(I_E = 2.5 mAdc, I_C = 0)	MRF208		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	MRF209		4.0	–	–	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 15 Vdc, I_E = 0)	MRF207		–	–	0.1	
	MRF208		–	–	0.25	
	MRF209		–	–	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MRF207		5.0	–	–	
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	MRF208		5.0	–	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	MRF209		5.0	–	–	
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, f = 220 MHz)	MRF207		8.2	12.5	–	
(V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 220 MHz)	MRF208		10	12.5	–	
(V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 220 MHz)	MRF209		4.4	5.2	–	
Input Impedance		Z_{in}				Ohms
(P_{out} = 1.0 W, f = 220 MHz)	MRF207		–	10-j11.5	–	
(P_{out} = 10 W, f = 220 MHz)	MRF208		–	1.4+j1.4	–	
(P_{out} = 25 W, f = 220 MHz)	MRF209		–	1.4+j1.8	–	
Output Impedance		Z_{out}				Ohms
(P_{out} = 1.0 W, f = 220 MHz)	MRF207		–	32 - j41	–	
(P_{out} = 10 W, f = 220 MHz)	MRF208		–	5.7 - j1.3	–	
(P_{out} = 25 W, f = 220 MHz)	MRF209		–	3.9 - j0.2	–	

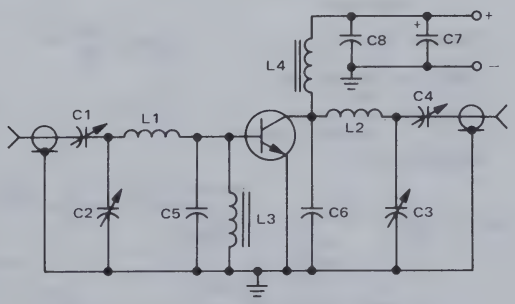
220 MHz TEST CIRCUIT

FIGURE 1 – MRF207



C1	2.0 - 50 pF	ARCO 461
C2, C4	5.0 - 80 pF	ARCO 462
C3	1.5 - 15 pF	ARCO 460
C5	40 pF	
C6	1000 pF	
C7	5.0 μF	TANTALUM
L1	1 Turn, #20 AWG, 1/4" ID	
L2	4 Turns, #20 AWG, 1/4 ID	
L3, L4	15 μH RFC	

FIGURE 2 – MRF208, MRF209



C1, C2, C3, C4	5.0 - 80 pF	ARCO 462
C5, C6	100 pF	
C7	10 μF	TANTALUM
C8	1000 pF	
L1	#14 AWG, 1¼" Long, Straight	
L2	1 Turn, #14 AWG, 3/8" ID	
L3, L4	RFC VK200	

OUTPUT POWER versus INPUT POWER
(V_{CC} = 12.5 Vdc, f = 220 MHz)

FIGURE 3 – MRF207

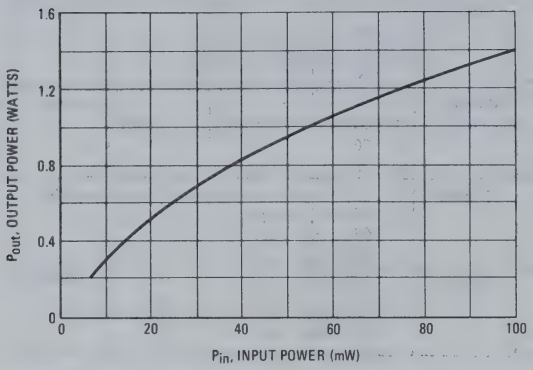


FIGURE 4 – MRF208

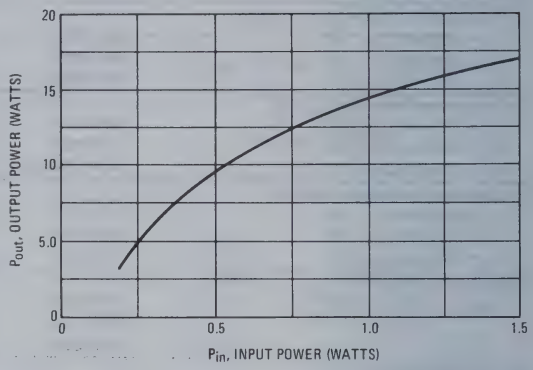


FIGURE 5 – MRF209

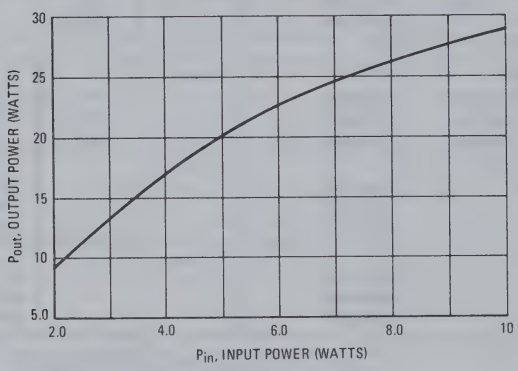
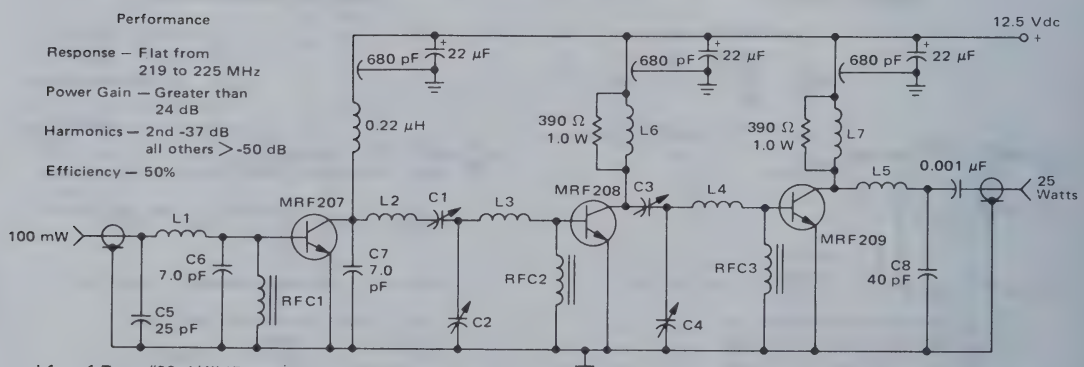
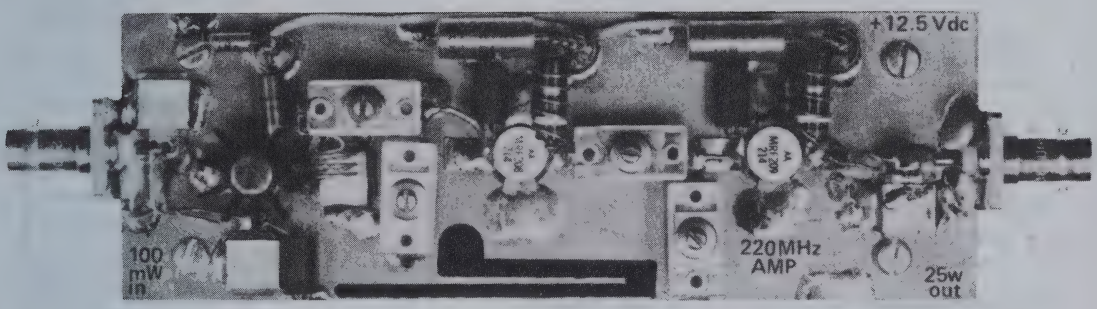


FIGURE 6 – 220-MHz, 25-WATT AMPLIFIER



L1	1 Turn, #20, 1/4" ID	RFC1	VK200 Ferroxcube	C1	2.0-25 pF, ARCO 421 or equivalent
L2	3 Turns, #20, 1/4" ID	RFC2	VK200 Ferroxcube	C2,C3,C4	7.0-100 pF, ARCO, 423 or equivalent
L3	1/3 Turn, #16, 3/8" ID	RFC3	VK200 Ferroxcube	C8	Underwocd or equivalent capacitor which is capable of high current without undue heating.
L4	1/3 Turn, #18, 1/4" ID				
L5	1 Turn, #20, 1/8" ID				
L6,L7	5 Turns, #20, 1/4" ID				


+12.5 Vdc
100 mW in
220 MHz AMP
25w out

MRF215 (SILICON)

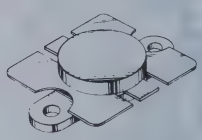
The RF Line

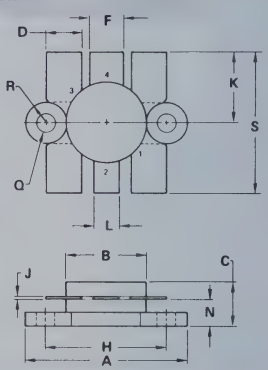
NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 20 Watts
  Minimum Gain = 8.2 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

20 W – 175 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE – ISOLATED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.59	5.84	0.220	0.230
H	18.24	18.59	0.718	0.732
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	4.45	4.70	0.175	0.185
N	4.06	4.45	0.160	0.175
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

NOTE:
1. DIM. "K" FROM CENTER OF "Q"

CASE 278-04

MAXIMUM RATINGS

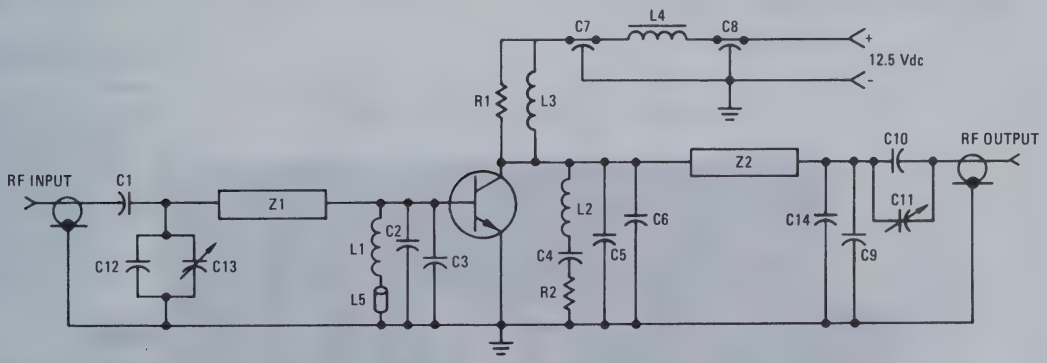
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	31 177	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	8.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	70	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	8.2	–	–	dB
Collector Efficiency (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	60	–	–	%
Load Mismatch (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1,C12	15 pF UNDERWOOD
C2,C3	40 pF UNDERWOOD
C4	0.1 μF, 100 V, ERIE
C5,C6,C10,C14	10 pF UNDERWOOD
C7,C8	680 pF ALLEN BRADLEY Feedthrough
C9	25 pF UNDERWOOD
C11,C13	1.0-10 pF JOHANSEN Type 3201
L1	0.15 μH Choke
L2	2 Turns, #24 AWG, 1/8" ID
L3	6 Turns, #20 AWG, on 390 Ohm, 2 W Resistor
L4	Ferrite Choke, FERROXCUBE VK-200-10-4B
L5	Ferrite Bead, FERROXCUBE 56-590-65-3B
R1	390 Ohm, 1/2 W, 10%
R2	2.7 Ohm, 1/4 W, 10%
Z1, Z2	MICROSTRIPLINE – 0.275" W x 4.13" L
Board – Glass Teflon, ϵ = 2.56, t = 0.062"	
Input/Output Connectors – Type N	

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

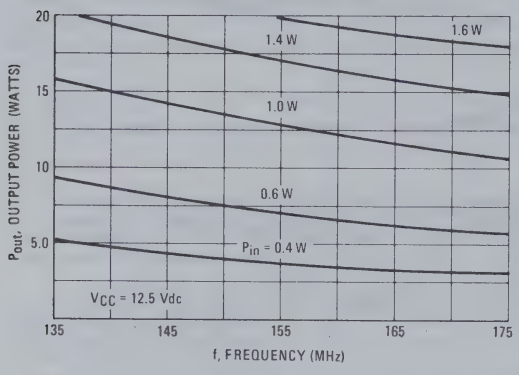


FIGURE 3 – OUTPUT POWER versus INPUT POWER

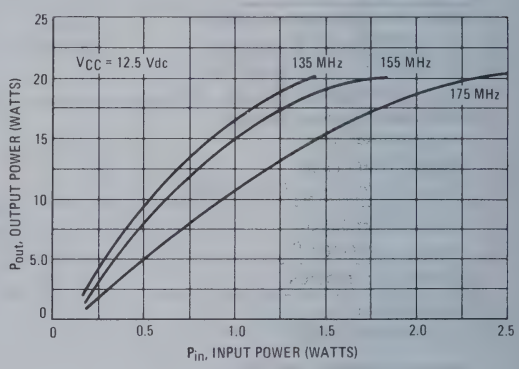


FIGURE 4 – TYPICAL GAIN versus FREQUENCY

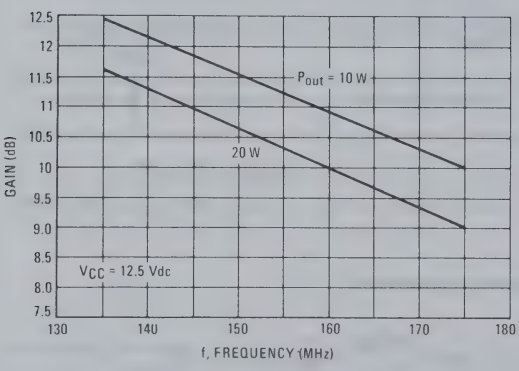


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS

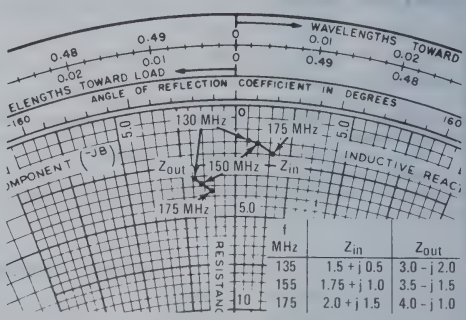
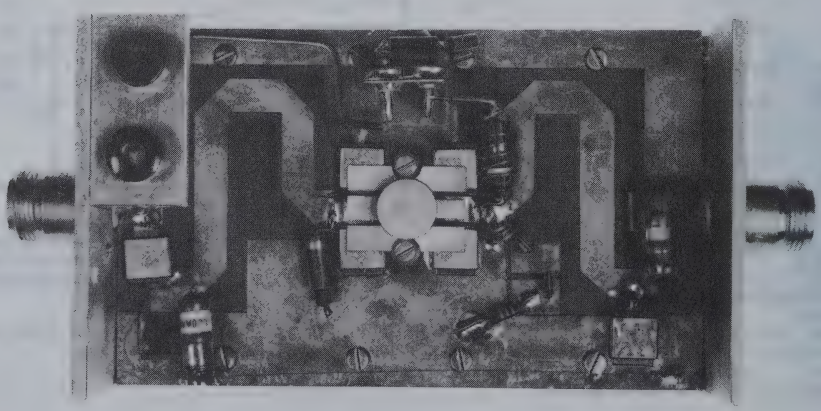


FIGURE 6 – 175 MHz TEST CIRCUIT LAYOUT



MRF216 (SILICON)

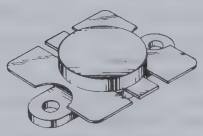
The RF Line

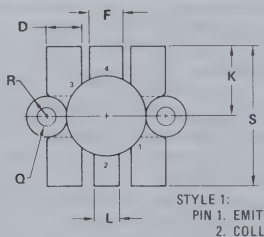
NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics—
  Output Power = 40 Watts
  Minimum Gain = 6.7 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

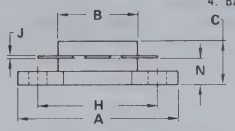
40 W — 175 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE

FLANGE – ISOLATED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.59	5.84	0.220	0.230
H	18.24	18.59	0.718	0.732
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	4.45	4.70	0.175	0.185
N	4.06	4.45	0.160	0.175
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

NOTE:
1. DIM. "K" FROM CENTER OF "Q".

CASE 278-04

MAXIMUM RATINGS

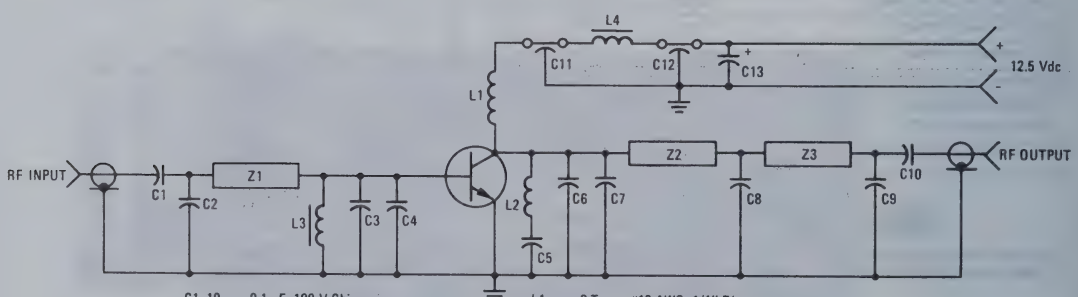
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	75 0.428	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	2.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	170	200	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	6.7	–	–	dB
Collector Efficiency (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	60	–	–	%
Load Mismatch (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz, VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1, 10	0.1 μF, 100 V Chip	L1	6 Turns, #18 AWG, 1/4" Dia.
C2, 3, 4	40 pF, UNELCO	L2	3 Turns, 1/8" Dia on Lead of C5
C5	0.1 μF, 100 V Disc Ceramic	L3, L4	FERRITE Choke. FERROXCUBE VK200-10-4B
C6, 7	10 pF, UNELCO	Z1	MICROSTRIPLINE, 0.300" Wide, 3.20" Long
C8	25 pF, UNELCO	Z2	MICROSTRIPLINE, 0.300" Wide, 0.50" Long
C9	60 pF, UNELCO	Z3	MICROSTRIPLINE, 0.300" Wide, 1.90" Long
C11, 12	680 pF, ALLEN BRADLEY Feedthru	Board – Glass Teflon, ϵ = 2.56, t = 0.062"	
C13	1.0 μF, 35 V, TANTALUM	Input/Output Connectors – Type N	

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

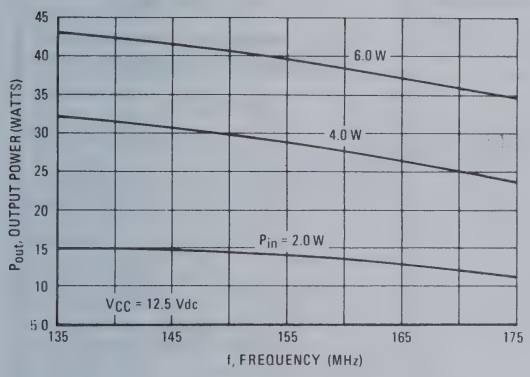


FIGURE 3 – OUTPUT POWER versus INPUT POWER

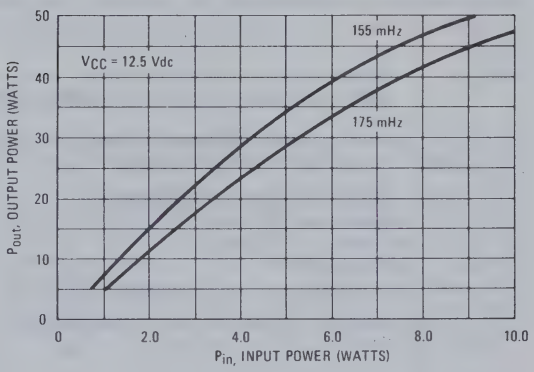


FIGURE 4 – TYPICAL GAIN versus FREQUENCY

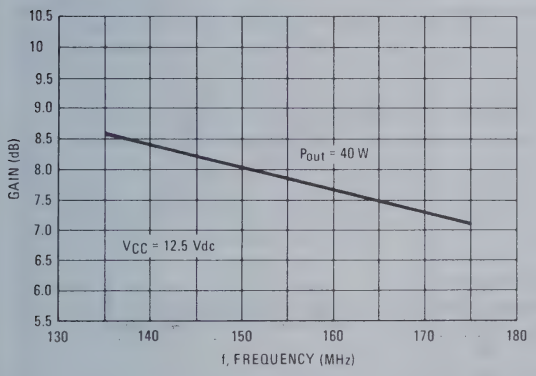


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS

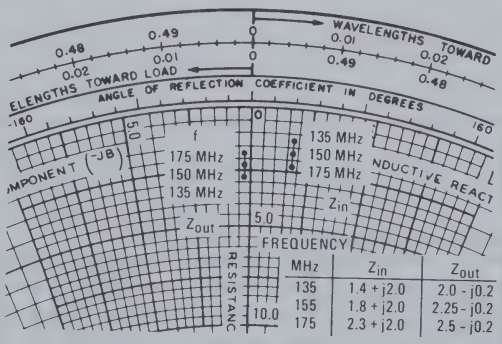
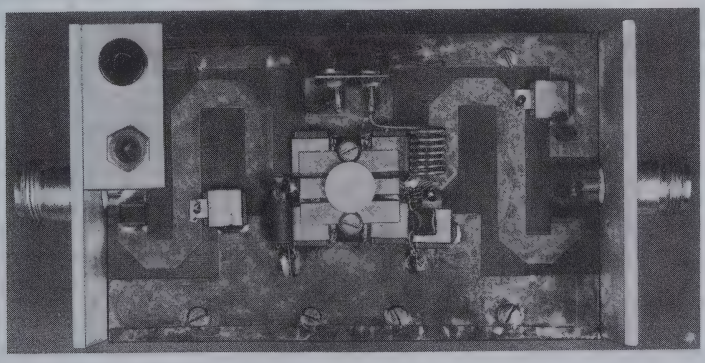


FIGURE 6 – 175 MHz TEST CIRCUIT LAYOUT



MRF304 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

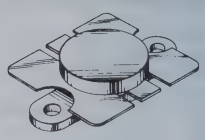
. . . designed primarily for wideband large-signal driver amplifier stages in the 225-400 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics –
  Output Power = 10 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 60%
- Built-In Matching Network for Broadband Operation
- 100% tested for Load Mismatch at all Phase Angles with 30:1 VSWR

10 W - 400 MHz

CONTROLLED "Q" RF POWER TRANSISTOR

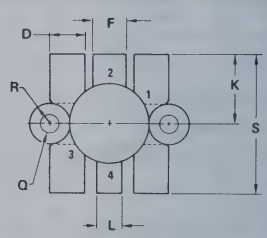
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	30 171	Watts $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.46 TYP		0.215 TYP	
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

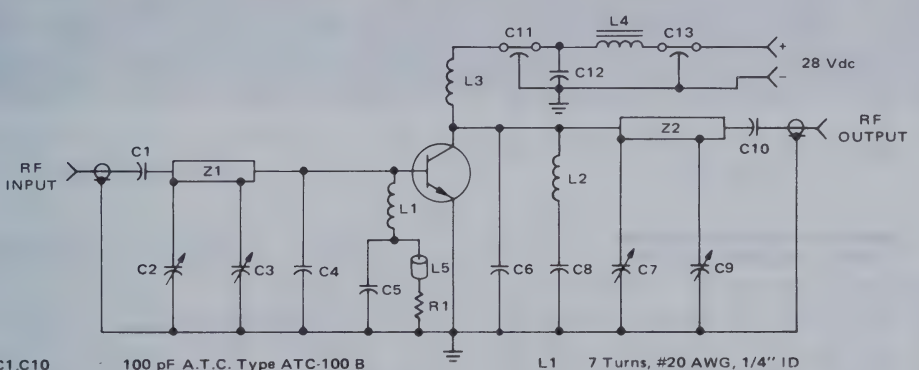
STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR
FLANGE-ISOLATED

CASE 278-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10 10	– –	100 –	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	21	25	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	G_{PE}	9.0	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	η	60	–	–	%
Electrical Ruggedness (P_{out} = 10 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1, all phase angles.)	–	No Degradation in P_{out}			–

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	100 pF A.T.C. Type ATC-100 B	L1	7 Turns, #20 AWG, 1/4" ID
C2,C3,C7,C9	1.0-20 pF, JOHANSON Type 3906	L2	1 Turn, 1/8" ID, lead of C8
C4	2, 10 pF UNDERWOOD (UNELCO) one on each side of the base lead	L3	7 Turns, #20 AWG, 1/4" ID
C5	100 pF UNDERWOOD (UNELCO)	L4	FERRITE Choke, FERROXCUBE VK200-20-4B
C6	2, 15 pF UNDERWOOD (UNELCO) one on each side of the collector lead	L5	FERRITE Bead on lead of R1, FERROXCUBE 56-590-65-3B
C8	0.1 μF, 100 V Disc Ceramic	Z1	MICROSTRIPLINE 0.2" W x 1.6" L, C2 Mounted 0.3 Inches From Start, C3 Mounted 1.1 Inches From Start
C11,C13	680 pF ALLEN BRADLEY Feedthru	Z2	MICROSTRIPLINE, 0.300" W x 1.70" L, C7 Mounted at Collector, C9 Mounted 0.4" From End
C12	1.0 μF, 35 V TANTALUM		
R1	2.7 Ohms, 1/2 W, 10%		

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062"
Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

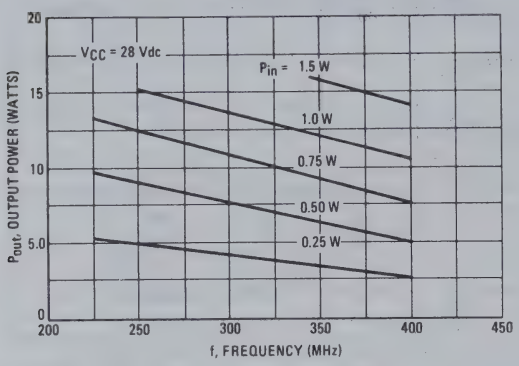


FIGURE 3 – OUTPUT POWER versus INPUT POWER

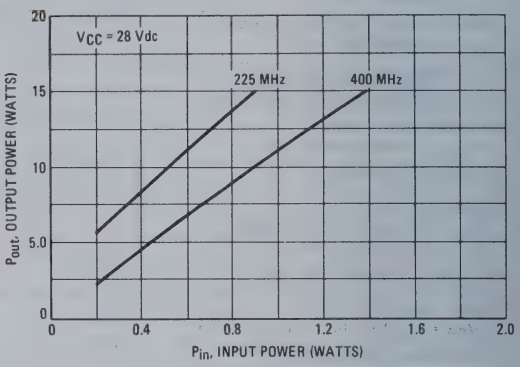


FIGURE 4 – POWER GAIN versus FREQUENCY

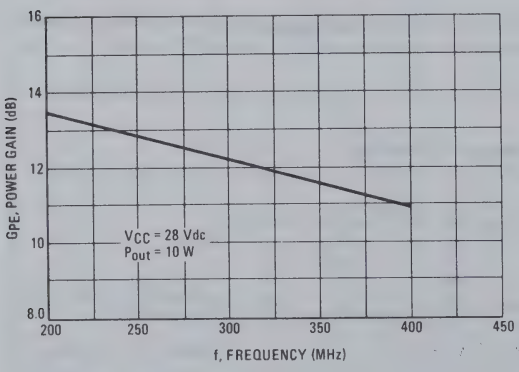


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE – 400 MHz

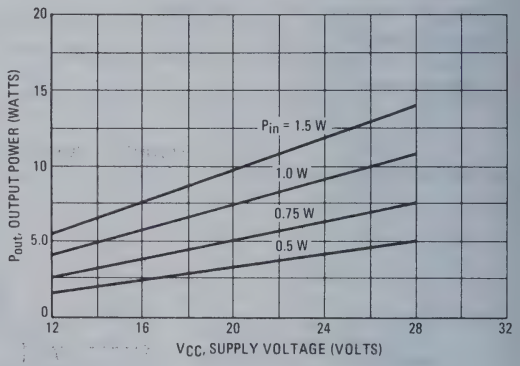


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE – 225 MHz

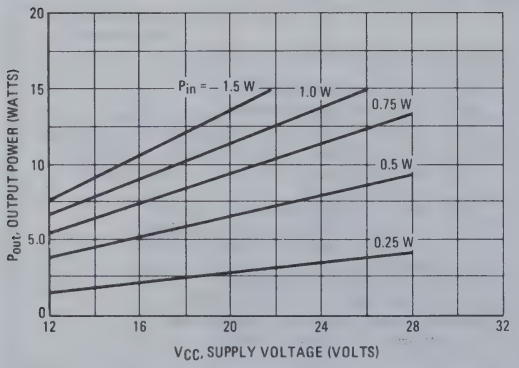
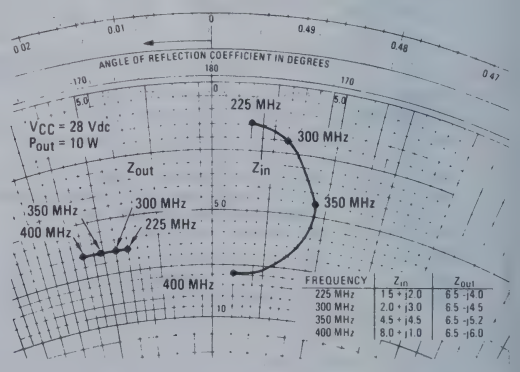
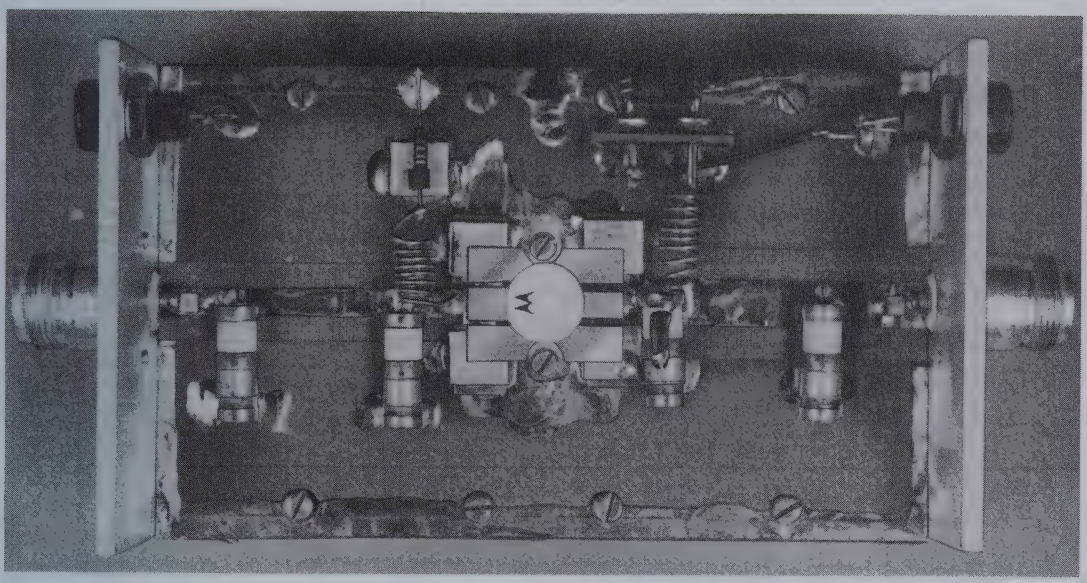


FIGURE 7 – SERIES EQUIVALENT IMPEDANCE



400 MHz TEST CIRCUIT

FIGURE 8



MRF305 (SILICON)

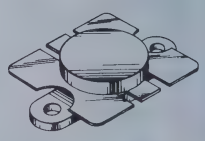
The RF Line

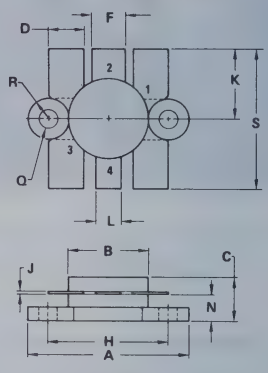
NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for wideband large-signal driver and output amplifier stages in the 225-400 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics –
  Output Power = 30 Watt
  Minimum Gain = 8.0 dB
  Efficiency = 55% (Min)
- Built-In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR

30 W-400 MHz
CONTROLLED "Q" RF POWER TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR
FLANGE-ISOLATED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.46 TYP		0.215 TYP	
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

CASE 278-03

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	70 0.4	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

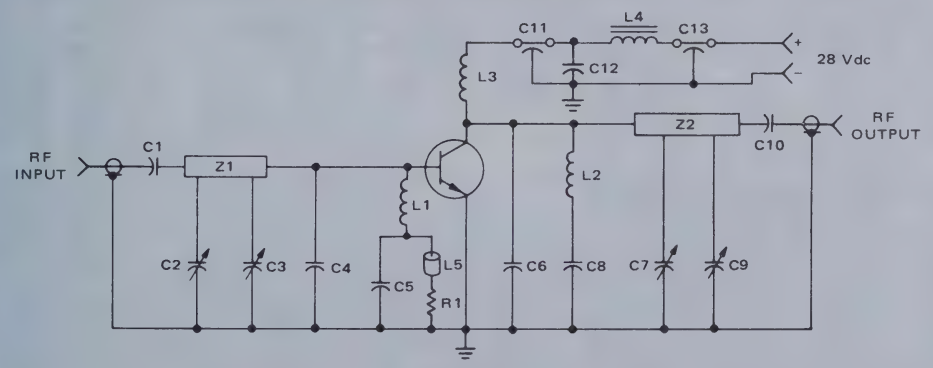
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 3.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10 10	– –	100 –	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	45	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	G_{PE}	8.0	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	η	55	–	–	%
Electrical Ruggedness (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1, all phase angles)	–	No Degradation in P_{out}			–

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	0.018 μF VITRAMON Chip Capacitor
C2,C3,C7,C9	1.0-20 pF JOHANSON Type 3906
C4	2, 10 pF UNDERWOOD (UNELCO) one each side of the Base Lead
C5	100 pF UNDERWOOD (UNELCO)
C6	2, 20 pF UNDERWOOD (UNELCO) one each side of the Collector Lead
C8	0.1 μF, 100 V Disc Ceramic
C11,13	680 pF ALLEN BRADLEY Feedthru
C12	1.0 μF, 35 V TANTALUM
R1	2.7 Ohm, 1/2 Watt, 10%
L1	3 Turns, #24 AWG, 1/8" ID
L2	2 Turns, Lead of C8, 1/8" ID
L3	5 Turns, #20 AWG, 1/4" ID
L4	FERRITE Choke, FERROXCUBE VK200-20-4B
L5	FERRITE Bead on Lead of R1, FERROXCUBE 56-590-65-3B
Z1	Microstrip Line, 0.2" W x 1.7" L C2 Mounted 0.3" from Start C3 Mounted 0.9" from Start
Z2	Microstrip Line, 0.3" W x 1.5" L C7 Mounted 0.8" from End C9 Mounted 0.2" from End
	Board – Glass Teflon ϵ_R = 2.56, t = 0.062 in.
	Input Output Connectors Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

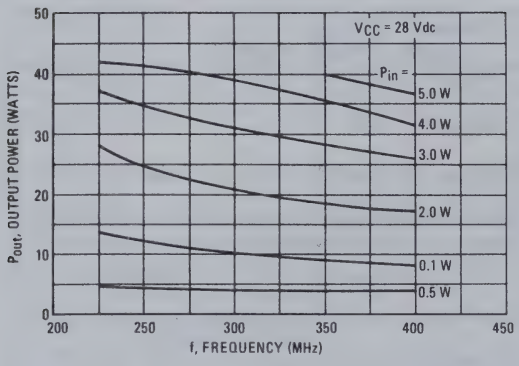


FIGURE 3 – OUTPUT POWER versus INPUT POWER

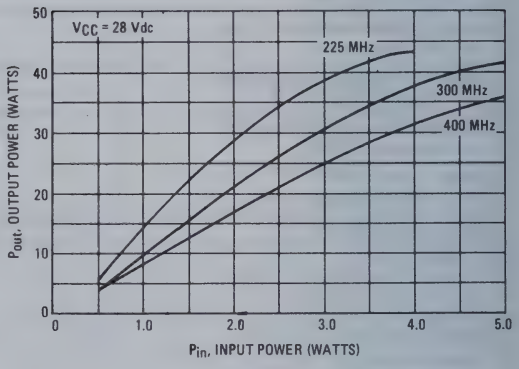


FIGURE 4 – POWER GAIN versus FREQUENCY

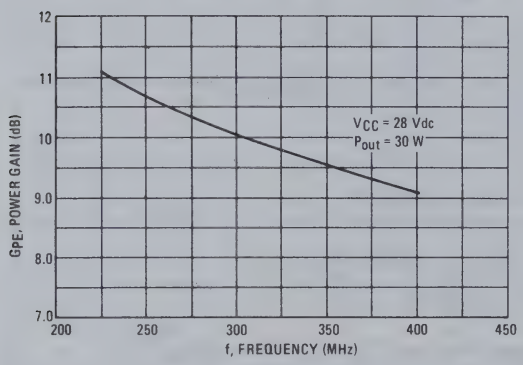


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE – 400 MHz

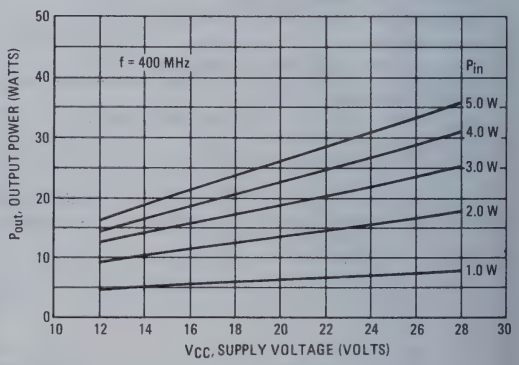


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE – 225 MHz

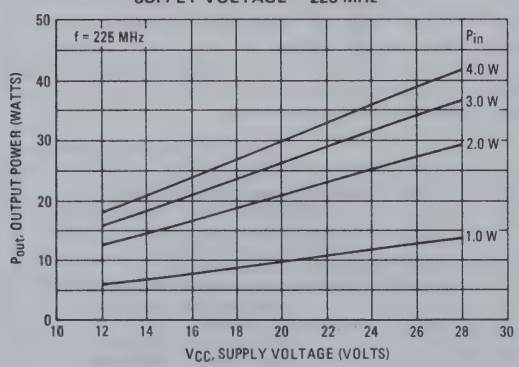
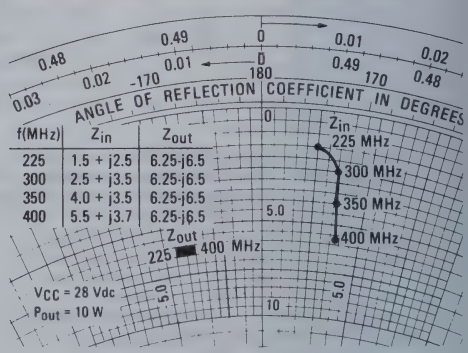


FIGURE 7 – SERIES EQUIVALENT IMPEDANCE



f(MHz)	Z_{in}	Z_{out}
225	1.5 + j2.5	6.25-j6.5
300	2.5 + j3.5	6.25-j6.5
350	4.0 + j3.5	6.25-j6.5
400	5.5 + j3.7	6.25-j6.5

FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER (PEP)

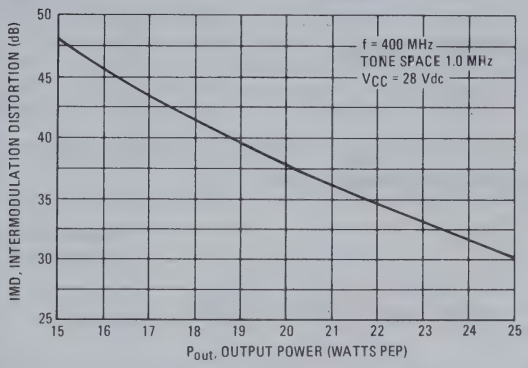
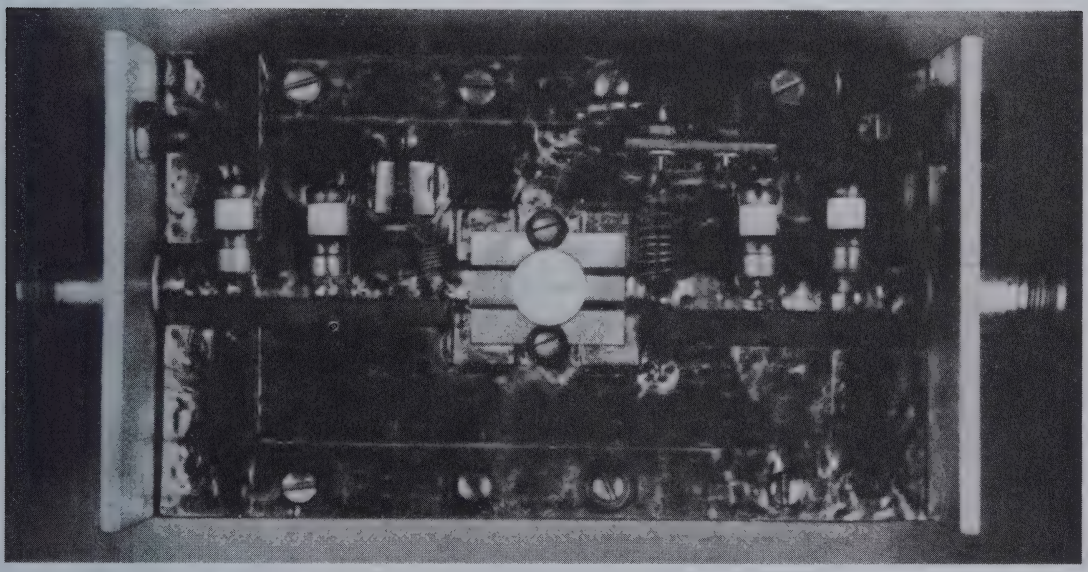


FIGURE 9 – 400 MHz TEST CIRCUIT



MRF401 (SILICON)

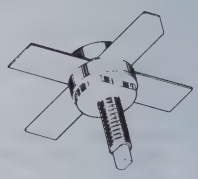
The RF Line

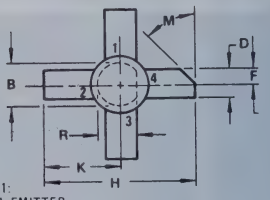
NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for applications as a high-power linear amplifier from 2.0 to 75 MHz.

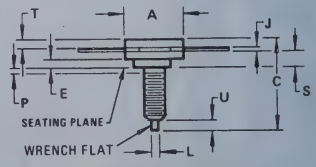
- Specified 28 Volt, 30 MHz Characteristics –
  Output Power = 25 W (PEP)
  Minimum Gain = 13 dB
  Efficiency = 40%
- Intermodulation Distortion at 25 W (PEP)
  IMD = -32 dB (Max)
- Isothermal-Resistor Design Results in Rugged Device

25 W PEP – 30 MHz
RF POWER
TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

MAXIMUM RATINGS

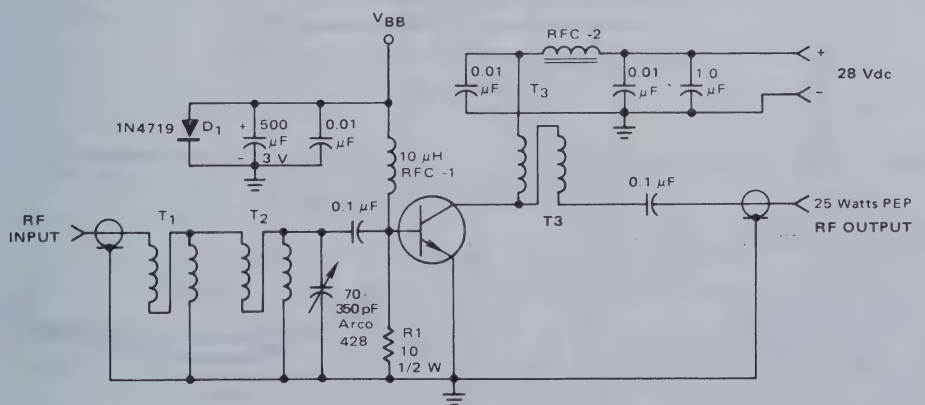
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	3.3	Adc
Total Device Dissipation @ $T_C = 25^oC$(1) Derate above 25^oC	P_D	50 28.6	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	20	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	65	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 25 Watts PEP, I_C (max) = 1.12 Adc, V_{CC} = 28 Vdc, f = 30 MHz)	G_{PE}	13	–	–	dB
Collector Efficiency (P_{out} = 25 Watts PEP, I_C (max) = 1.12 Adc, V_{CC} = 28 Vdc, f = 30 MHz)	η	40	–	–	%
Intermodulation Distortion (P_{out} = 25 Watts PEP, I_C = 1.12 Adc, V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IM	–	–	-32	dB

FIGURE 1 – 25 WATT, 2-30 MHz BROADBAND AMPLIFIER TEST CIRCUIT



T_1, T_3 4:1 6 Turns of 2 Twisted Pairs of #26 AWG Enameled Wire (6 Crest Per Inch) Wound on Stackpole 57 9322 #11 Toroid.

T_2 4:1 4 Turns of 4 Twisted Pairs of #26 AWG Enameled Wire (6 Crest Per Inch) Wound on Stackpole 57 9322 #11 Toroid.

RFC -2 Ferroxcube VK200 19/4B Ferrite Choke

NOTE: Adjust V_{BB} for I_C = 20 mAdc with no RF drive present.

FIGURE 2 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

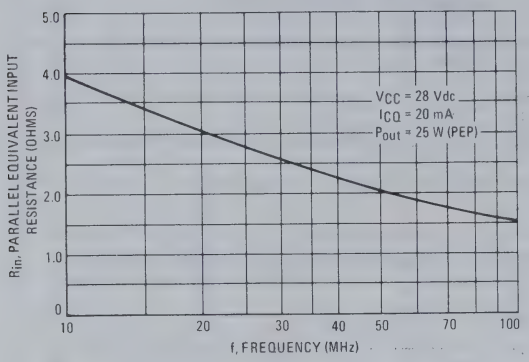


FIGURE 3 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

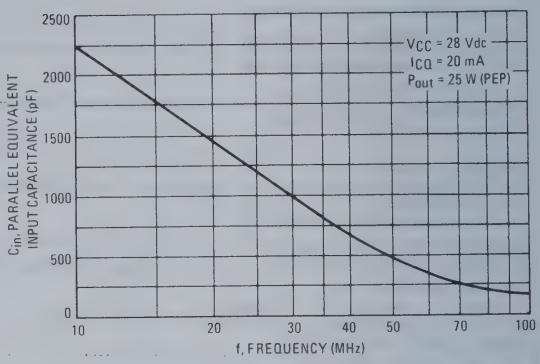


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

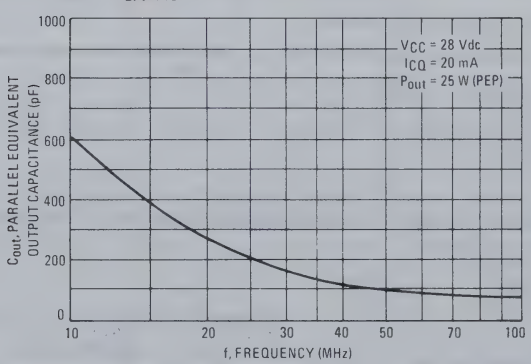


FIGURE 5 – POWER GAIN versus FREQUENCY

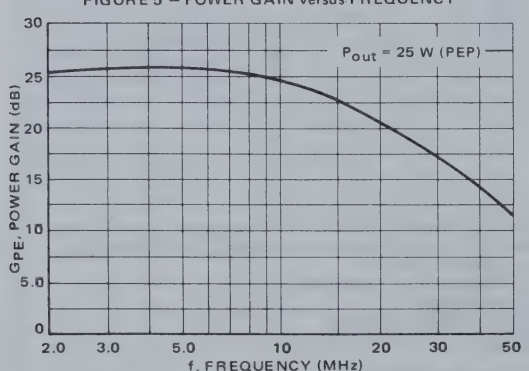
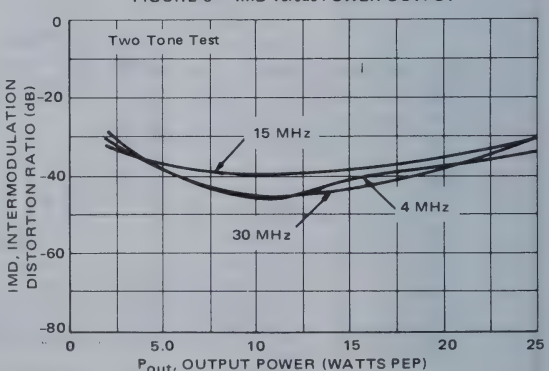


FIGURE 6 – IMD versus POWER OUTPUT



MRF501 (SILICON)
MRF502

The RF Line

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

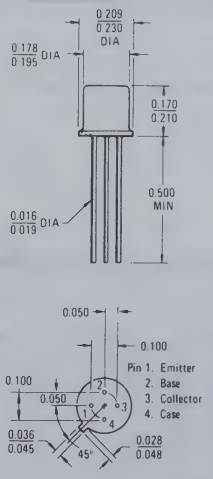
- High Current-Gain — Bandwidth Product —
  f_T = 1.2 GHz (Typ) @ I_C = 5.0 mAdc
- Low Noise Figure —
  NF = 4.0 dB (Typ) @ f = 200 MHz

NPN SILICON
RF SMALL-SIGNAL
TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MRF501	MRF502	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	25	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Storage Temperature Range	T_{stg}	−65 to +200		°C



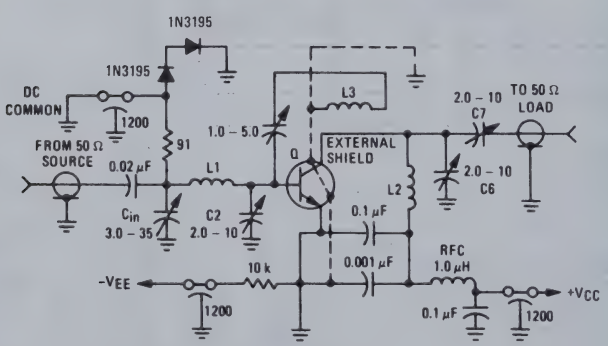
CASE 20(10)
TO-72 PACKAGE

Active Elements Isolated from Case

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)		BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	MRF501 MRF502	BV_{CBO}	25 35	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 1.0 Vdc, I_E = 0)	MRF501 MRF502	I_{CBO}	– –	– –	50 20	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	MRF501 MRF502	h_{FE}	30 40	– –	250 170	–
DYNAMIC CHARACTERISTICS						
Current Gain – Bandwdith Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	MRF501 MRF502	f_T	600 800	1000 1200	– –	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)		C_{cb}	–	0.6	–	pF
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	8.0	–	ps
Noise Figure (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	MRF501 MRF502	NF	– –	4.5 4.0	– –	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CC} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	MRF501 MRF502	G_{pe}	– –	15 17	– –	dB

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT



L1 13/4 Turns, #18 AWG, 0.5" Long, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" Long, 0.5" Diameter
L3 2 Turns, #18 AWG, 0.25" Long, 0.5" Diameter, Position Approximately 0.25" from L2

MRF509 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

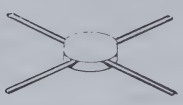
. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver or predriver stages in VHF and UHF applications.

- 2N3866 – Packaged for Stripline Designs
- High Power Gain @ 400 MHz
  G_{PE} = 10 dB @ V_{CC} = 28 Vdc

1 W – 400 MHz

RF POWER TRANSISTOR

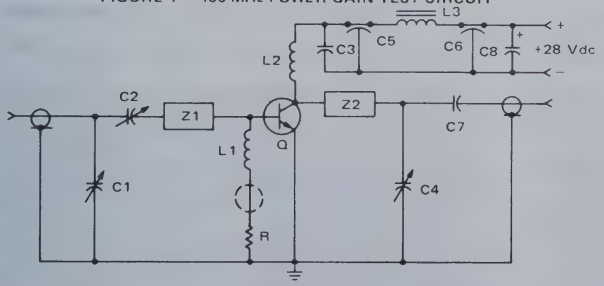
NPN SILICON



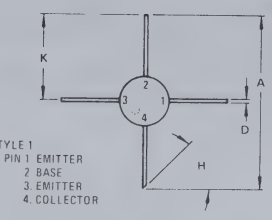
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C	P_D	2.0	Watts
Derate Above 25°C		11.4	W/°C
Storage Temperature Range	T_{stg}	–65 to +200	°C

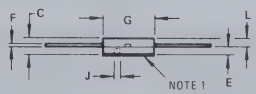
FIGURE 1 – 400 MHz POWER GAIN TEST CIRCUIT



C1, C2, C4	1.0-20 pF (Johanson 9063)	R	4.7 Ohms, 1/4 W
C3	0.1 μF	Z1	2.0" x 0.1" Strip
C5, C6	680 pF Feedthru	Z2	5.3" x 0.1" Strip
C7	150 pF Chip	L1, L2	5 T AWG #20, 1/4" I.D.
C8	1.0 μF Tantalum	L3	FERROXCUBE VK200
		Q	MRF509



STYLE 1
PIN 1 EMITTER
2 BASE
3 EMITTER
4 COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	37.730	36.270	1.328	1.428
C	2.790	3.300	0.110	0.130
D	0.635	0.889	0.025	0.035
E	1.400	1.650	0.055	0.065
F	0.330	0.432	0.013	0.017
G	6.990	7.370	0.275	0.290
H	40°	50°	40°	50°
J	0.686	0.838	0.027	0.033
K	16.870	18.140	0.664	0.714
L	1.400	1.650	0.055	0.065

NOTE
1. BOTTOM SIDE GOLD PLATED.

CASE 207A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ω)	BV_{CER}	55	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	0.02	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	–	200	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	1000	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.2	3.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (P_{out} = 1.0 W, V_{CC} = 28 Vdc, f = 400 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 28 Vdc, f = 400 MHz)	η	40	–	–	%

FIGURE 2 – OUTPUT POWER versus INPUT POWER

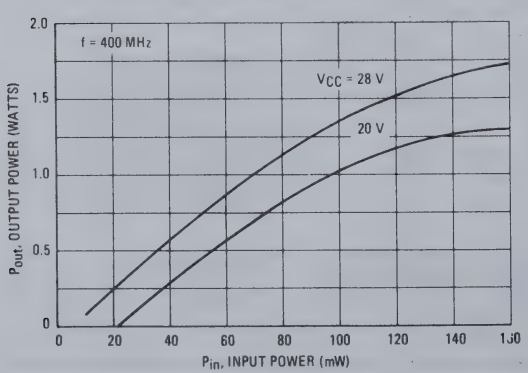


FIGURE 3 – OUTPUT POWER versus FREQUENCY

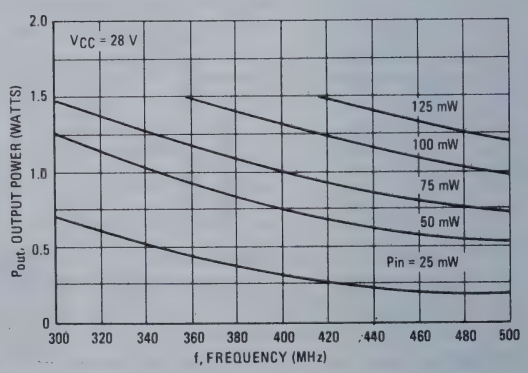


FIGURE 4 – CURRENT-GAIN-BANDWIDTH PRODUCT

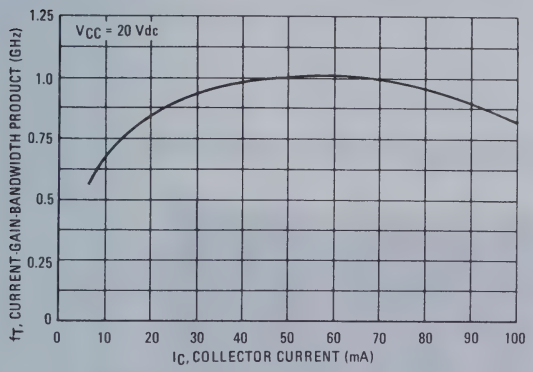
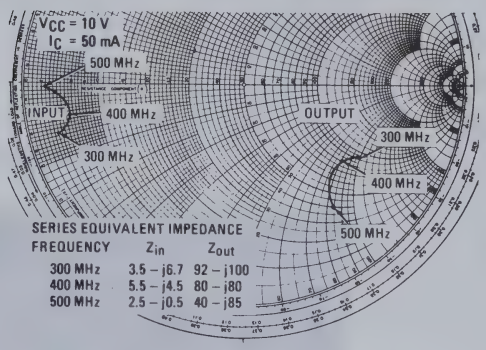


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



SERIES EQUIVALENT IMPEDANCE

FREQUENCY	Z_{in}	Z_{out}
300 MHz	3.5 – j6.7	92 – j100
400 MHz	5.5 – j4.5	80 – j80
500 MHz	2.5 – j0.5	40 – j85

FIGURE 6 – S11, INPUT REFLECTION COEFFICIENT

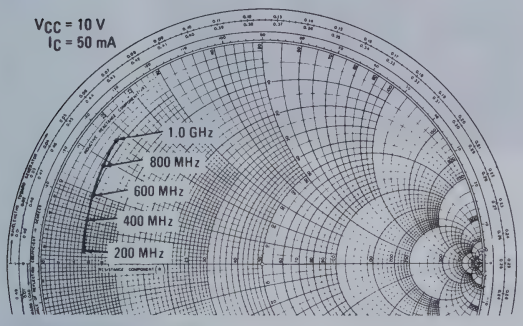


FIGURE 7 – S22, OUTPUT REFLECTION COEFFICIENT

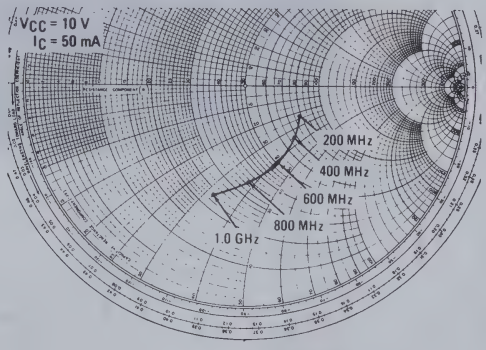


FIGURE 8 – S12, REVERSE TRANSMISSION COEFFICIENT

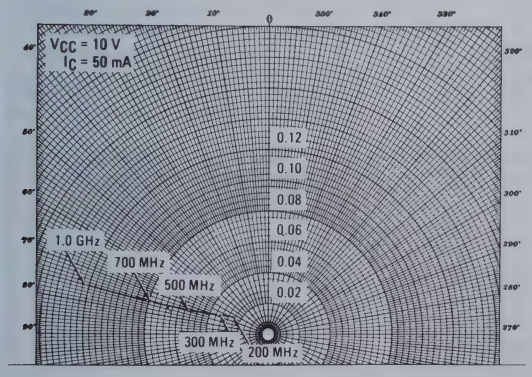


FIGURE 9 – S21, FORWARD TRANSMISSION COEFFICIENT

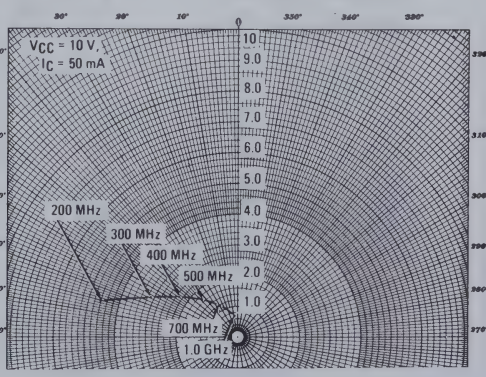
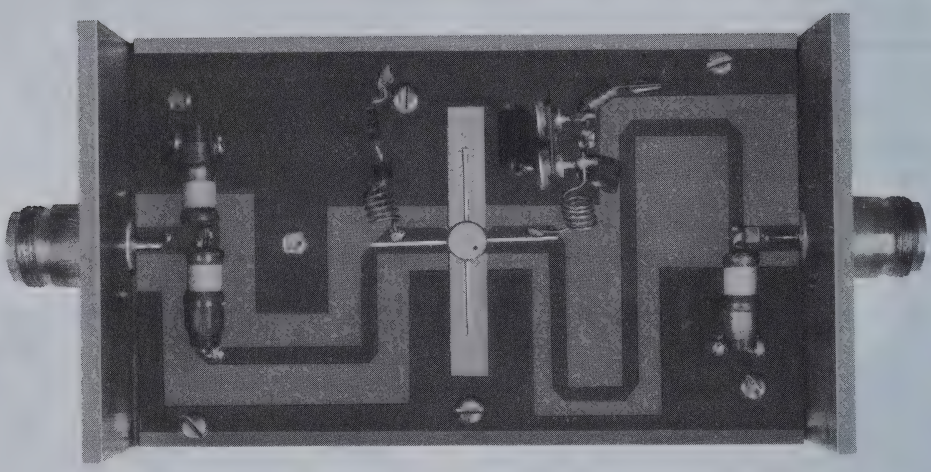


FIGURE 10 – 400 MHz TEST CIRCUIT



MRF603 (SILICON)

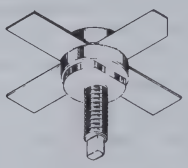
The RF Line

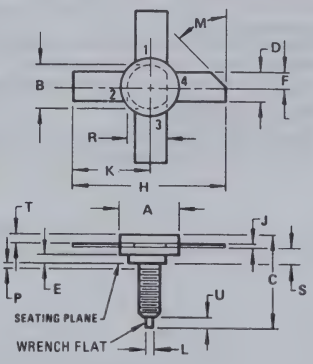
10 W – 175 MHz
RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal power amplifier applications required in military and industrial equipment operating to 300 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 10 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	30 171	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	in. lb.

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

(2) For repeated assembly use 5 in.lb.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

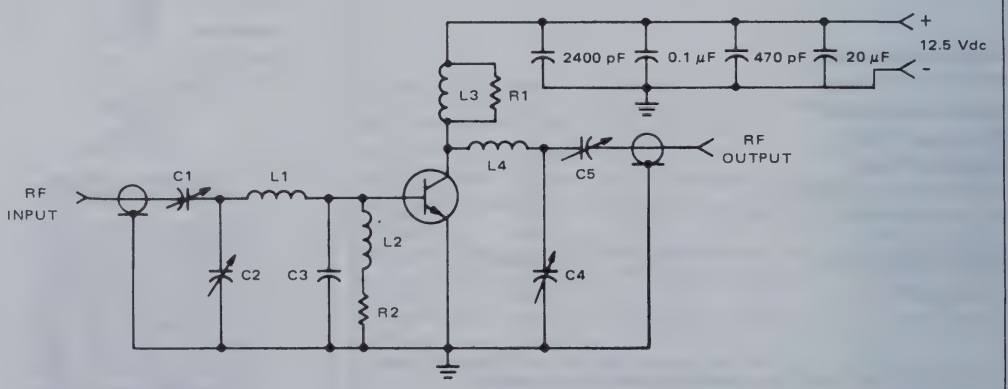
NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	8.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	70	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1, C5 5.0-80 pF, ARCO 462 or equivalent
C2 9.0-180 pF, ARCO 463 or equivalent
C3 120 pF
C4 25-280 pF, ARCO 464 or equivalent
L1 Copper Strap, 1-1/4" L, 1/4" W, 0.03" Thick
L2 Ferrite Choke VK-200-20/4B FERROXCUBE (Ferrite Bead near Base)
L3 6 Turns # 16 AWG, Wrapped on R1
L4 30 nH, 1 Turn # 16 AWG, 1-1/4" Length, 1/4" I.D.
R1 100 Ohms, 2 W
R2 1.5 Ohms, 1/4 W

MRF607 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military, mobile, marine and citizens band equipment. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 1.75 Watts
  Minimum Gain = 12.5 dB
  Efficiency = 50%
- Characterized through 225 MHz

1.75 W – 175 MHz

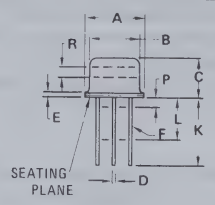
RF POWER TRANSISTOR NPN SILICON

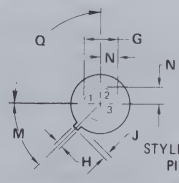


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	0.33	Adc
Total Device Dissipation @ $T_C = 75^oC$ (1) Derate above 75^oC	P_D	3.5 28	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.





STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

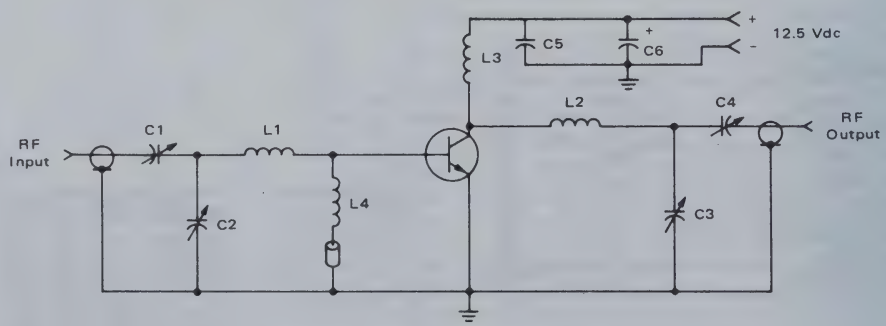
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

CASE 79-02
TO-39
All JEDEC notes and dimensions apply.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	BV_{CEO}	16	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	–	0.3	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	150	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	15	pF
FUNCTIONAL TEST (Figure 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	12.5	–	dB
Collector Efficiency (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1	2.7-15 pF, ARCO 461	L1	1 Turn #20 AWG, 3/8" ID
C2	9.0-180 pF, ARCO 463	L2	3 Turns #20 AWG, 3/8" ID
C3,C4	5.0-80 pF, ARCO 462	L3	0.22 μH Molded Choke
C5	1000 pF UNELCO	L4	0.15 μH Molded Choke with FERROXCUBE 56-590-65-3B Bead on ground lead
C6	5 μF, 25 Vdc, TANTALUM		

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

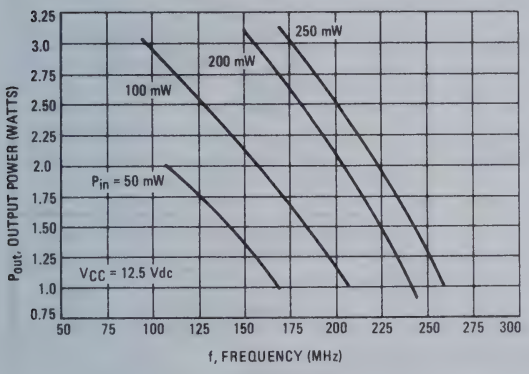


FIGURE 3 – OUTPUT POWER versus INPUT POWER

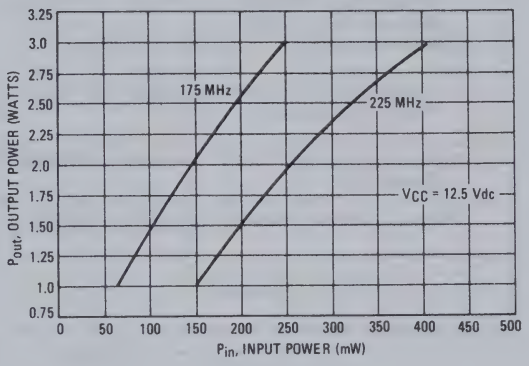


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

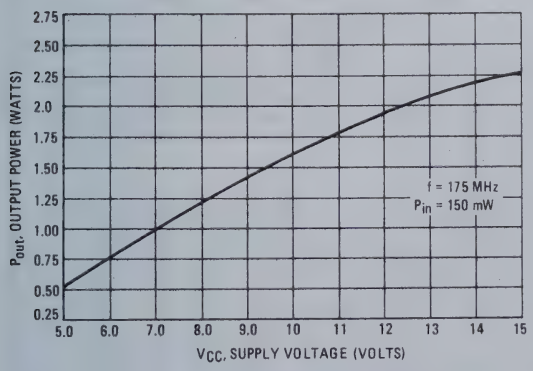
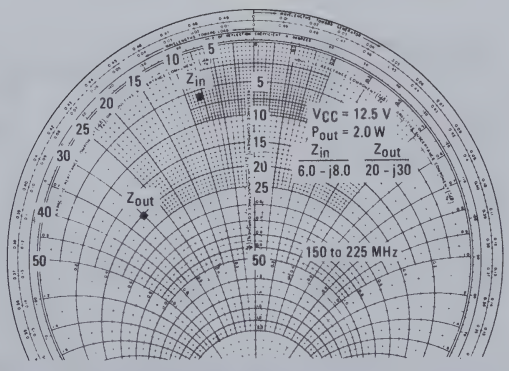


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



MRF618 (SILICON)

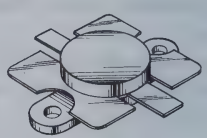
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 520 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 15 Watts
  Minimum Gain = 6.0 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

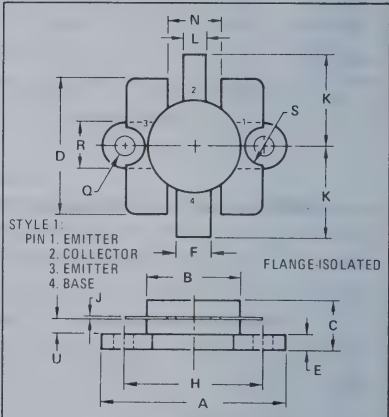
15 W – 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	45 0.257	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.51	25.15	.965	.990
B	12.45	12.95	.490	.510
C	5.97	7.62	.235	.300
D	18.29	19.30	.720	.760
E	2.16	2.67	.085	.105
F	4.32	4.57	.170	.180
H	18.29	18.54	.720	.730
J	.10	.15	.004	.006
K	12.19	12.70	.480	.500
L	3.05	3.30	.120	.130
N	6.86	7.11	.270	.280
Q	2.79	3.18	.110	.125
R	6.10	6.60	.240	.260
S	2.67	3.05	.105	.120
U	1.65	1.91	.065	.075

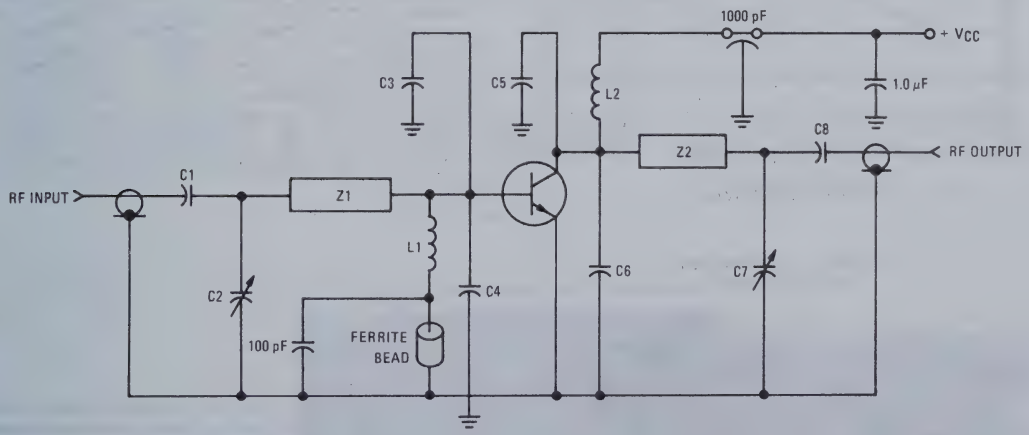
NOTE:
DIMENSION "Q" IS DIA., DIMENSION "S" IS RAD.

CASE 278-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	200	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	65	80	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	G_{PE}	6.0	7.0	–	dB
Collector Efficiency (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	η	60	–	–	%
Electrical Ruggedness (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz, VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 – 470 MHz TEST CIRCUIT SCHEMATIC



C1, C8 100 pF, UNELCO OR EQUIVALENT
C2 1.0-10 pF, JOHANSON 2951
C3, C4, C5, C6 15 pF, UNELCO OR EQUIVALENT
C7 1.0-20 pF, JOHANSON 3906

L1, L2 3 TURNS #20 AWG, 1/8" I.D.
FERRITE BEAD FERROXCUBE 56-590-65-3B

Z1 0.2" WIDTH x 1.0" LENGTH
Z2 0.28" WIDTH x 1.0" LENGTH

BOARD IS GLASS TEFLON
3x5 x 0.062 INCH 1 oz COPPER
BOTH SIDES

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

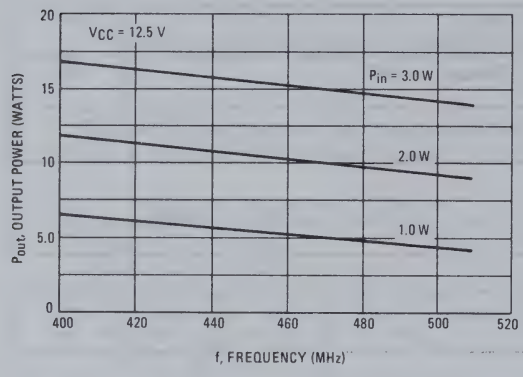


FIGURE 3 – OUTPUT POWER versus INPUT POWER

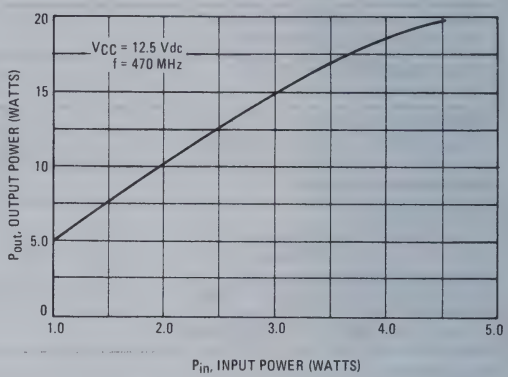


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

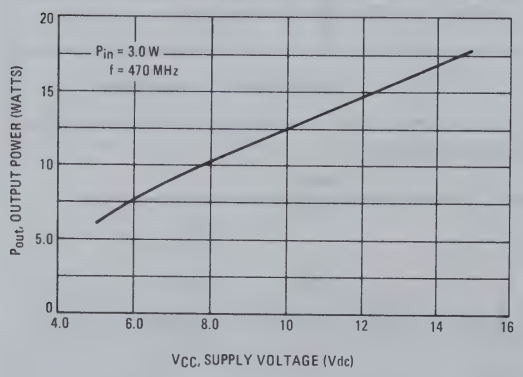


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS

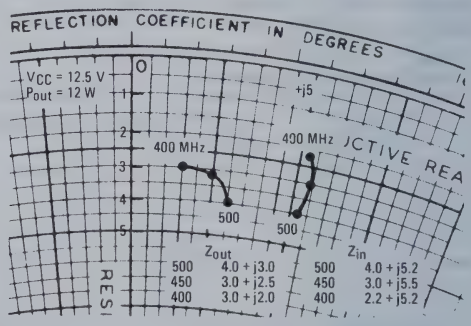
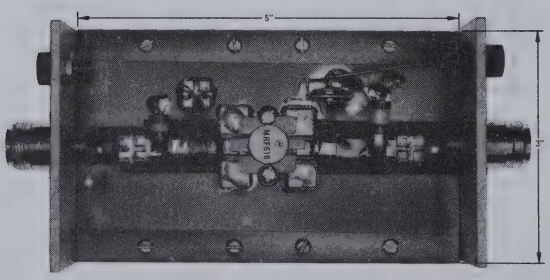


FIGURE 6 – 470 MHz TEST CIRCUIT LAYOUT



The series equivalent impedance values shown in Figure 5 are an average of a large sample of devices. These impedances are highly dependent on the following conditions: input power, output power, supply voltage, harmonic termination and base bias (if any). These variables can cause changes to ±30% from the typical values shown.

Application Note AN-548, "Microstrip Design Techniques for UHF Amplifiers", should be referenced for UHF power amplifier designs.

WIDEBAND UHF AMPLIFIER

460 MHz Typical Performance

P_{in} = 120 mW

P_{out} = 11 W

I_C = 1.8 A

FIGURE 7 –

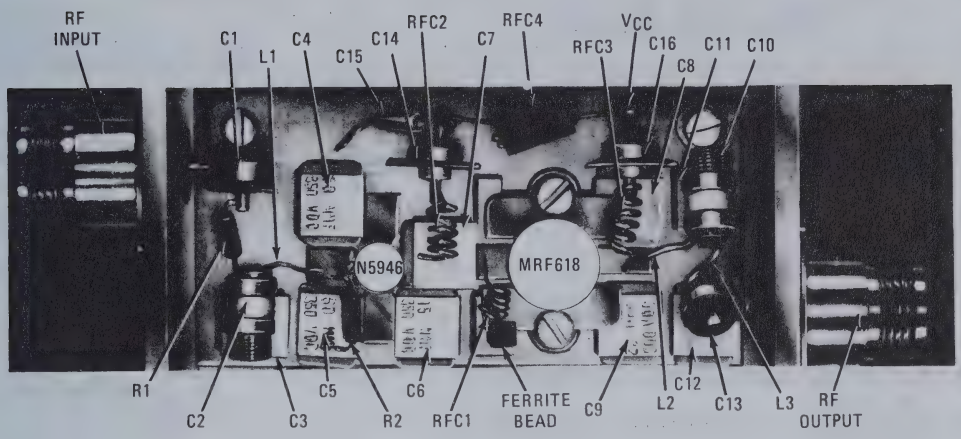
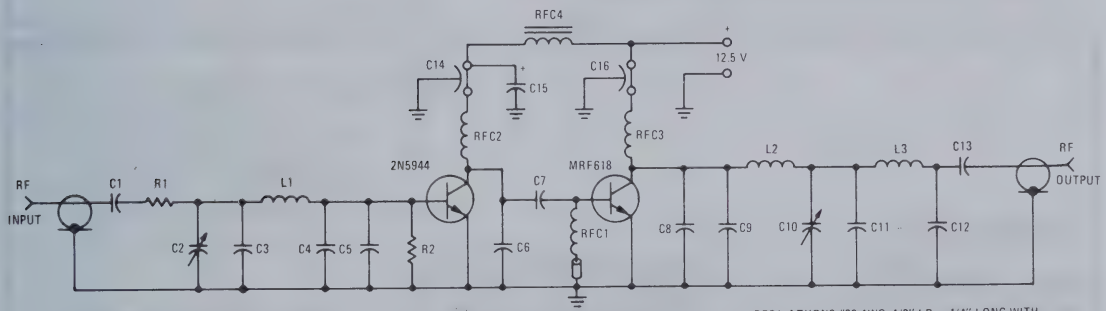


FIGURE 8 –



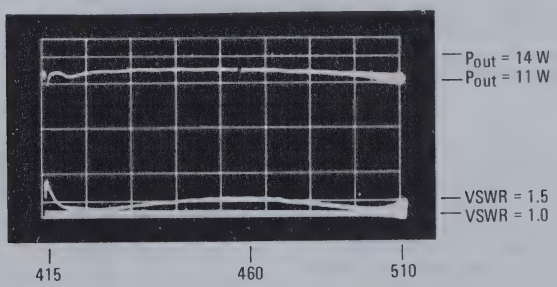
C1, 13, 14, 16 680 pF, ALLEN-BRADLEY FEEDTHRU.
C2, 10 1.0-10 pF, JOHANSON 2951
C3 10 pF UNDERWOOD OR EQUIVALENT
C4, 5 60 pF UNDERWOOD OR EQUIVALENT
C6, 8 15 pF UNDERWOOD OR EQUIVALENT

C7 100 pF UNDERWOOD OR EQUIVALENT
C9 25 pF UNDERWOOD OR EQUIVALENT
C11 7.0 pF UNDERWOOD OR EQUIVALENT
C12 5.0 pF UNDERWOOD OR EQUIVALENT
C15 1.0 μF 35 V TANTALUM

L1 0.5 INCH, #24 AWG
L2 0.5 INCH, #18 AWG
L3 0.375 INCH, #18 AWG

RFC1 4 TURNS #26 AWG, 1/8" I.D. x 1/4" LONG WITH FERRITE BEAD (FERROXCUBE) ON GROUND END
RFC 2,3 5 TURNS #22 AWG, 1/8" I.D. x 1.4" LONG
RFC 4 FERROXCUBE VK200
R1 2.7 Ω 1/4 WATT
R2 3.9 Ω 1/4 WATT
CIRCUIT BUILT ON P.C. BOARD 2 OZ COPPER

FIGURE 9 – WIDEBAND SWEPT RESPONSE



SWEPT POWER OUTPUT AND INPUT VSWR V_{CC} = 12.5 V P_{in} 150 mW

MRF619 (SILICON)
MRF620

The RF Line

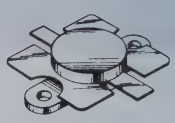
NPN SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 510 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 25 Watts – MRF619
  35 Watts – MRF620
  Minimum Gain = 5.22 dB – MRF619
  4.3 dB – MRF620
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation

25 W – 470 MHz – MRF619
35 W – 470 MHz – MRF620

"CONTROLLED Q"
RF POWER TRANSISTORS
NPN SILICON



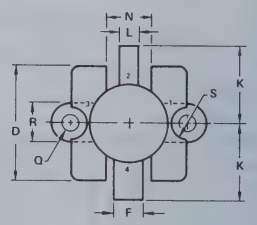
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector - Emitter Voltage		V_{CEO}	16	Vdc
Collector - Base Voltage		V_{CBO}	36	Vdc
Emitter - Base Voltage		V_{EBO}	4.0	Vdc
Collector Current — Continuous	MRF619	I_C	6.0	Adc
	MRF620		8.0	
Total Device Dissipation @ $T_C = 25^oC$ (1)		P_D	115	Watts
Derate above 25^oC			0.667	$W/^oC$
Storage Temperature Range		T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class C RF amplifiers.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.51	25.15	.965	.990
B	12.45	12.95	.490	.510
C	5.97	7.62	.235	.300
D	18.29	19.30	.720	.760
E	2.16	2.67	.085	.105
F	4.32	4.57	.170	.180
H	18.29	18.54	.720	.730
J	.10	.15	.004	.006
K	12.19	12.70	.480	.500
L	3.05	3.30	.120	.130
N	6.86	7.11	.270	.280
Q	2.79	3.18	.110	.125
R	6.10	6.60	.240	.260
S	2.67	3.05	.105	.120
U	1.65	1.91	.065	.075

NOTE:
DIMENSION "Q" IS DIA., DIMENSION "S" IS RAD.

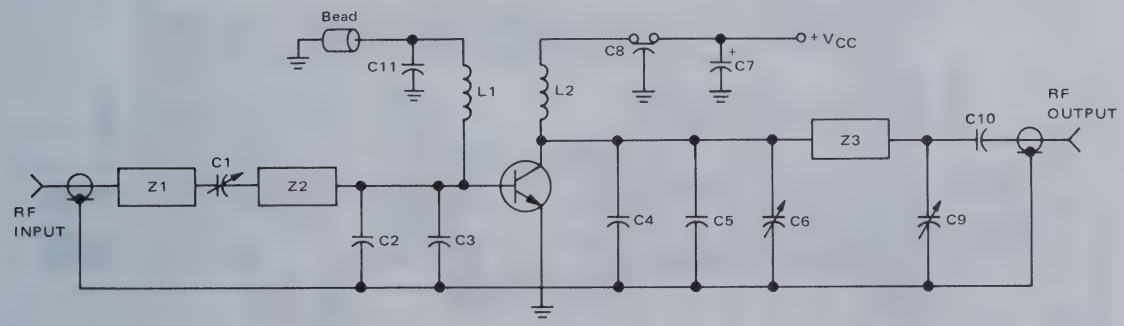
STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

CASE 278-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 15 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	–	20	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	85	95	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain	G_{PE}				dB
(V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz) MRF619		5.22	–	–	
(V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz) MRF620		4.3	–	–	
Collector Efficiency	η				%
(V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz) MRF619		55	–	–	
(V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz) MRF620		55	–	–	
Electrical Ruggedness (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz, VSWR = 20:1, All phase angles) MRF619 (V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz, VSWR = 20:1, All phase angles) MRF620	–	No Degradation in output power			

FIGURE 1 – 470 MHz TEST CIRCUIT



C1, C9 1.0-20 pF JOHANSON 3906 or equivalent
C2, C4 25 pF UNELCO or equivalent
C3, C5 15 pF UNELCO or equivalent
C6 1.0-10 pF JOHANSON 2951 or equivalent
C7 1.0 µF, 35 V TANTALUM
C8 680 pF Feedthru
C10, C11 100 pF UNELCO or equivalent

L1 4 Turns #22 AWG, 0.125 I.D.
L2 3 Turns #20 AWG, 0.250 I.D.

Z1 0.160" W X 1.7" L
Z2 0.230" W X 0.9" L
Z3 0.340" W X 0.9" L

FERROXCUBE Bead 56-590-65-3B

Board is glass teflon, ϵ_R = 2.56
3" x 5" x 0.062", 1 oz.
COPPER DOUBLE CLAD

OUTPUT POWER versus FREQUENCY

(V_{CC} = 12.5 Vdc)

FIGURE 2 – MRF619

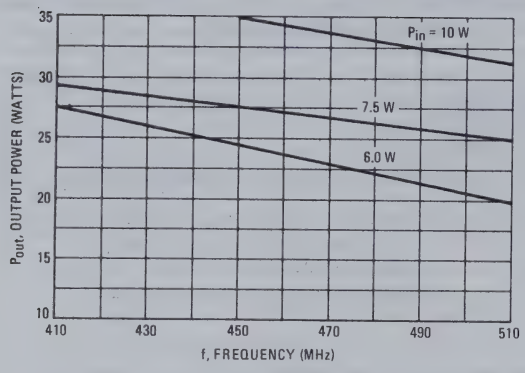
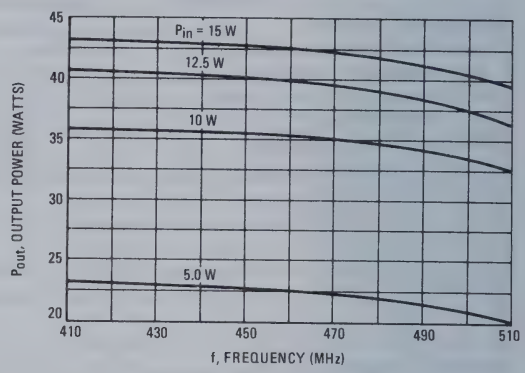


FIGURE 3 – MRF620



OUTPUT POWER versus INPUT POWER

(V_{CC} = 12.5 Vdc)

FIGURE 4 – MRF619

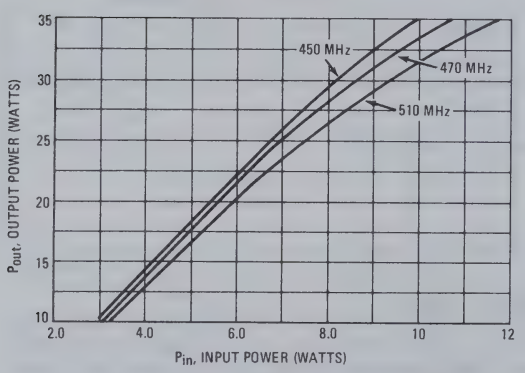
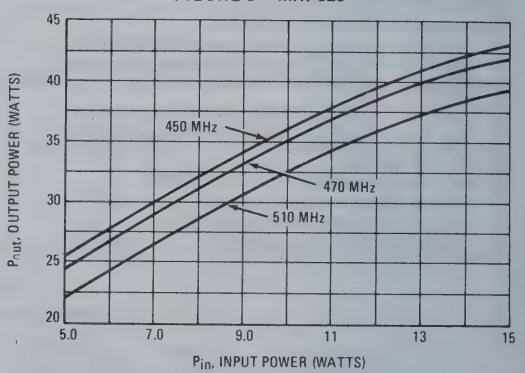


FIGURE 5 – MRF620



OUTPUT POWER versus SUPPLY VOLTAGE

(f = 470 MHz)

FIGURE 6 – MRF619

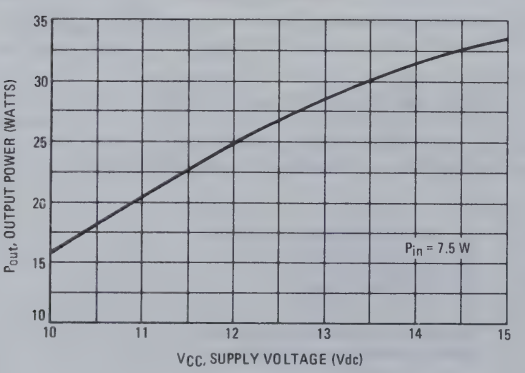
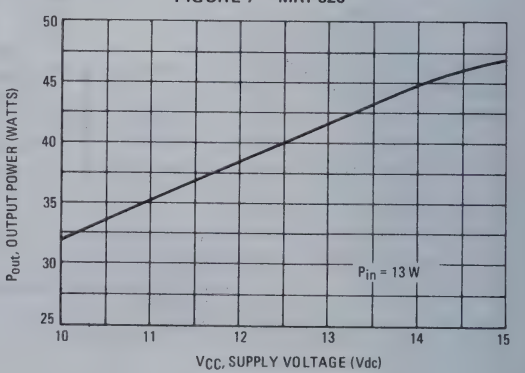


FIGURE 7 – MRF620



SERIES EQUIVALENT IMPEDANCE

(V_{CC} = 12.5 Vdc)

FIGURE 8 – MRF619

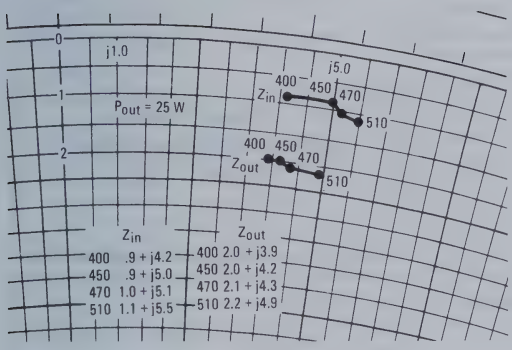


FIGURE 9 – MRF620

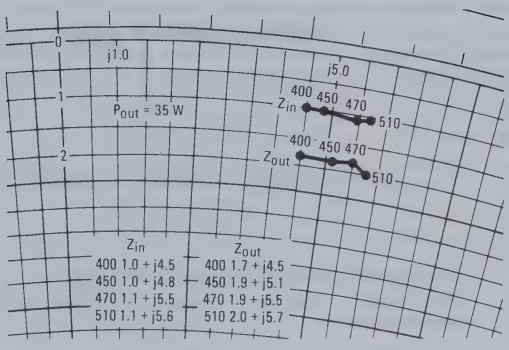
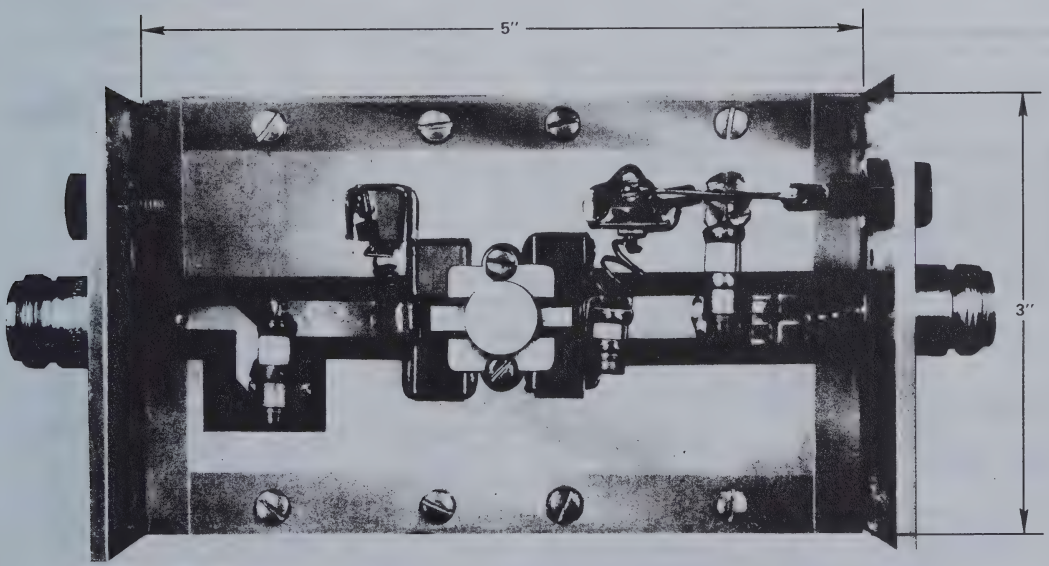


FIGURE 10 – 470 MHz TEST CIRCUIT LAYOUT



MRF5177 (SILICON)

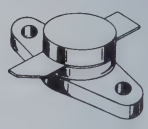
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF/UHF power amplifier applications. This device is optimized for rugged performance in 225-400 MHz communications equipment.

- Performance @ 400 MHz, 28 Vdc –
  Power Output = 30 W (Min)
  Gain = 6.0 dB (Min)
- Isothermal Design for Rugged Performance –
  Tested at 30:1 VSWR through all phase angles

30 W, 400 MHz
RF POWER TRANSISTOR
NPN SILICON



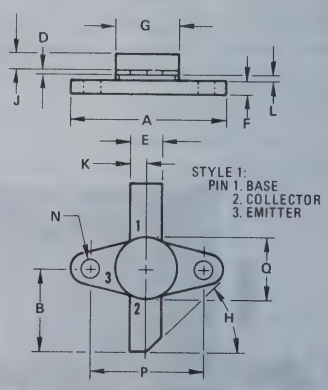
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$) (1) Derate Above 25^oC	P_D –	58 0.33	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

(1) This device is designed for RF Power operation. The total device dissipation rating applies only when the device is operated as a Class C RF Amplifier.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	$^oC/W$



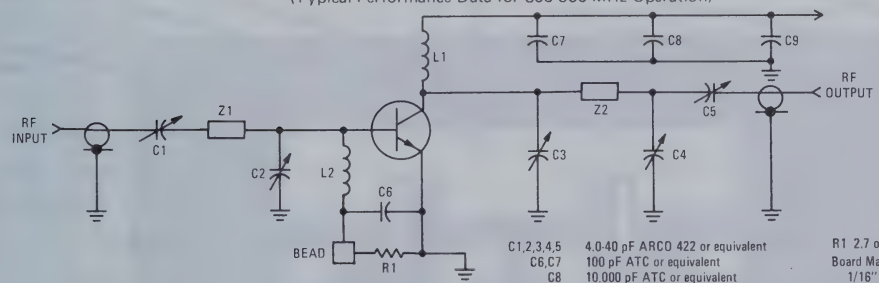
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	21.080	21.590	0.830	0.850
B	13.080	13.590	0.515	0.535
D	0.102	0.152	0.004	0.006
E	5.580	5.840	0.220	0.230
F	2.030	2.410	0.080	0.095
G	9.270	9.780	0.365	0.385
H	45^o MIN		45^o MIN	
J	2.030	2.540	0.080	0.100
K	2.790	2.930	0.110	0.115
L	1.520	2.030	0.060	0.080
N	2.920	3.180	0.115	0.125
P	15.110	15.370	0.595	0.605
Q	9.910	10.410	0.390	0.410

CASE 215

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10 10	100 –	–
DYNAMIC CHARACTERISTICS				
Output Capactiance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	50	pF
FUNCTIONAL TESTS (Figures 1 and 9)				
Common-Emitter Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz)	G_{PE}	6.0	–	dB
Collector Efficiency (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz)	η	60	–	%
Saturated Power (P_{in} = 11 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{sat}	36	–	Watts
Electrical Ruggedness (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz, $T_C \leq 50°C$)	VSWR > 30:1 through all phase angles in a 3 second time interval, After which, devices will meet G_{PE} test limits.			

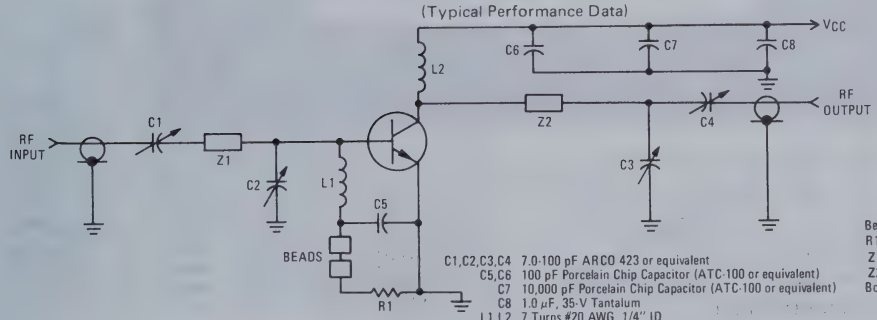
FIGURE 1 – 400 MHz TEST CIRCUIT
(Typical Performance Data for 300-500 MHz Operation)



C1,2,3,4,5 4.0-40 pF ARCO 422 or equivalent
C6,C7 100 pF ATC or equivalent
C8 10,000 pF ATC or equivalent
C9 1.0 μF, 35 V Tantalum
L1,L2 4 Turns, #20 AWG, 1/4" ID
L3 Ferrite Bead, Ferroxcube 56-590-65/3B

R1 2.7 ohms, 1/4 W, Carbon
Board Material:
1/16" Teflon Fiberglass
1 oz. copper, two-sided
Z1 0.3" Width, x 2.7" Length
Z2 0.3" Width, x 2.7" Length

FIGURE 2 – 200-300 MHz TEST CIRCUIT
(Typical Performance Data)



C1,C2,C3,C4 7.0-100 pF ARCO 423 or equivalent
C5,C6 100 pF Porcelain Chip Capacitor (ATC-100 or equivalent)
C7 10,000 pF Porcelain Chip Capacitor (ATC-100 or equivalent)
C8 1.0 μF, 35-V Tantalum
L1,L2 7 Turns #20 AWG, 1/4" ID

Beads, Ferroxcube 56-590 65/3B
R1 2.7 ohms, 1/2 W, Carbon
Z1 0.3" Width x 3.31" Length
Z2 0.3" Width x 4.53" Length
Board Material:
1/16" Glass-Teflon
1 oz. Copper, 2-sided

FIGURE 3 – OUTPUT POWER versus FREQUENCY

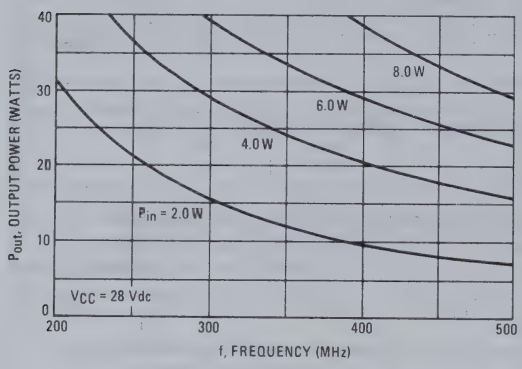


FIGURE 4 – OUTPUT POWER versus INPUT POWER

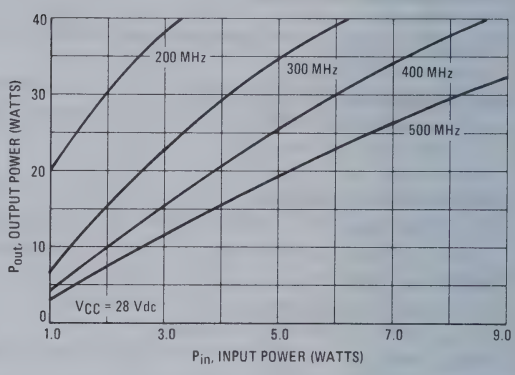


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

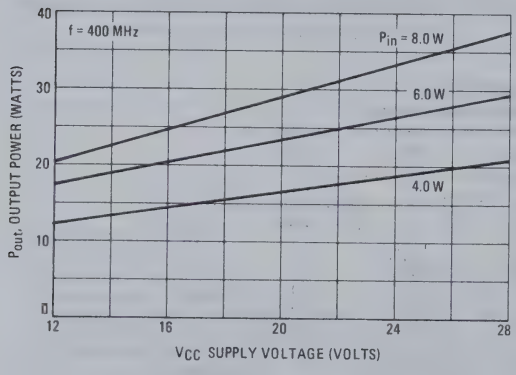


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE

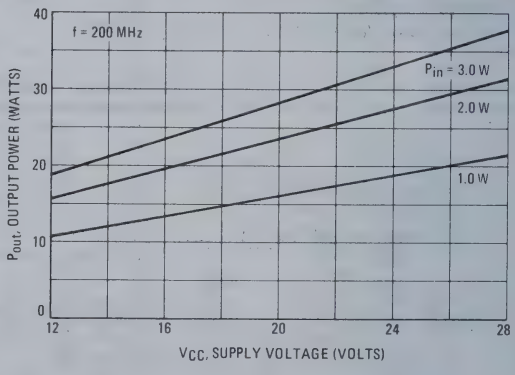


FIGURE 7 RF POWER DERATING

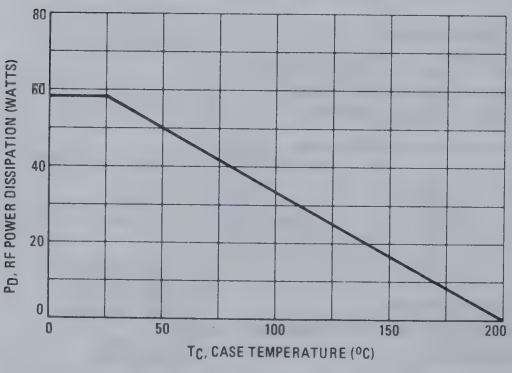


FIGURE 8 – SERIES EQUIVALENT IMPEDANCE

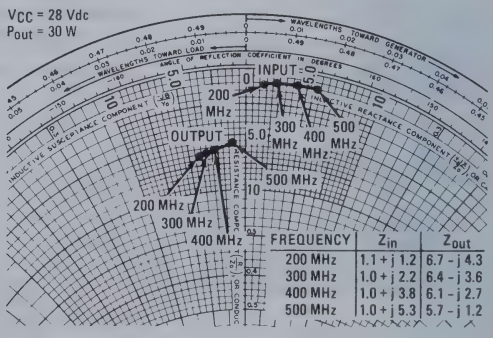
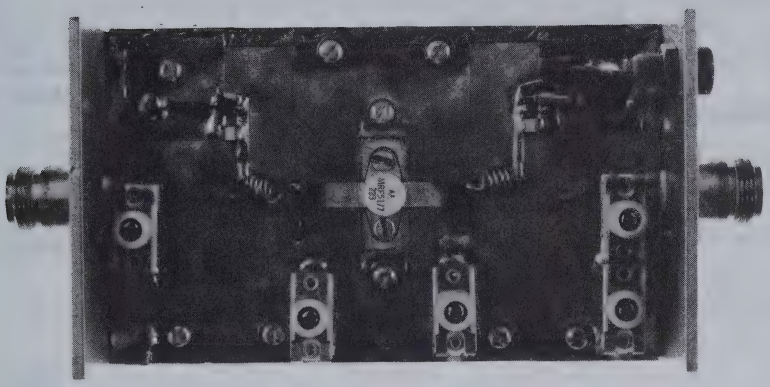
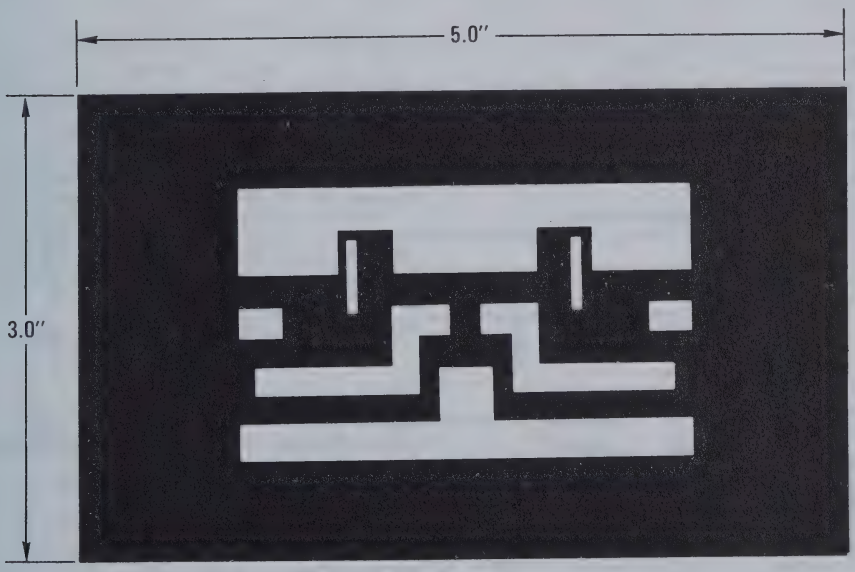


FIGURE 9 – 400 MHz CIRCUIT LAYOUT





MRF8004 (SILICON)

The RF Line

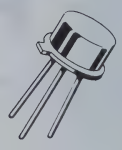
NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large-signal output amplifier stages. Intended for use in Citizen-Band communications equipment operating to 30 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits.

- Specified 12.5 V, 27 MHz Characterisitcs –
  Power Output = 3.5 W
  Power Gain = 10 dB
  Efficiency = 70% Typical

3.5 W – 27 MHz RF POWER TRANSISTOR

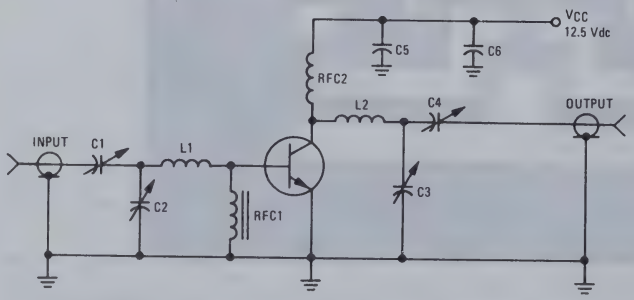
NPN SILICON



MAXIMUM RATINGS

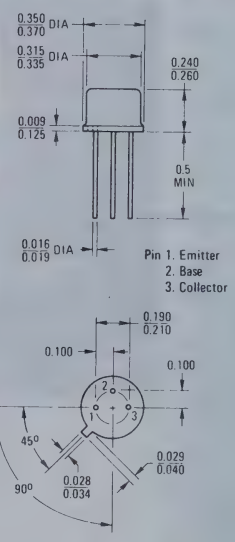
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2 9.0-180 pF ARCO 463 or Equivalent
C3, C4 5.0-80 pF ARCO 462 or Equivalent
C5 0.02 μF Ceramic Disc
C6 0.1 μF Ceramic Disc
RFC1 4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2 26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) ¼" Inner Diameter
L1 0.22 μH Molded Choke
L2 0.68 μH Molded Choke

(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.



All JEDEC dimensions and notes apply

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 400 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	35	70	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (2) (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	η	62.5	70	–	%
Percentage Up-Modulation (1) (See Figure 1) (f = 27 MHz)	–	–	85	–	%
Parallel Equivalent Input Resistance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	R_{in}	–	21	–	Ohms
Parallel Equivalent Input Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{in}	–	900	–	pF
Parallel Equivalent Output Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{out}	–	200	–	pF

(1) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 12.5 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \bullet 100$$

(2) $$\eta = \frac{R_F\ P_{out}}{(V_{CC})\ (I_C)} \bullet 100$$

FIGURE 2 – CIRCUIT TUNED AT 25 V, 25% DUTY CYCLE, P_{out} = 15 W PEAK

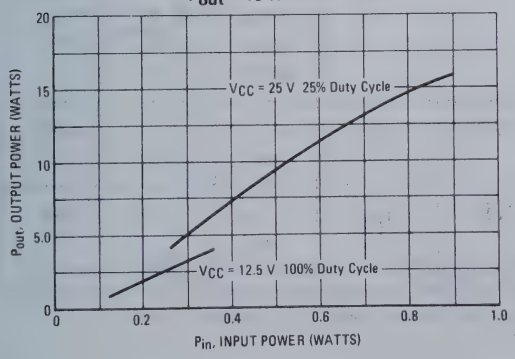
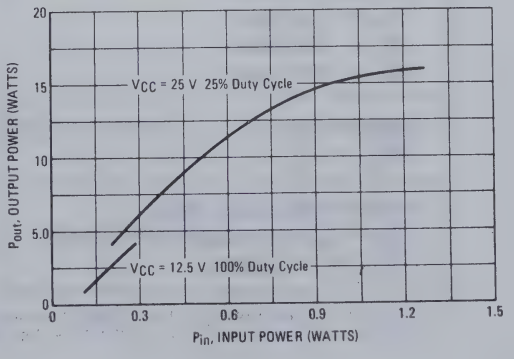


FIGURE 3 – CIRCUIT TUNED AT 12.5 V, P_{out} = 4 W



MSD6100 (SILICON)



Silicon epitaxial dual switching diode, designed for use in high speed switching applications, features high breakdown voltage, low capacitance and space saving common-cathode configuration.



CASE 29 (3)
(TO-92)



PIN 1. ANODE
2. ANODE
3. CATHODE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	135	°C
Storage Temperature Range	T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	—	$V_{(BR)}$	100	—	Vdc
Reverse Current (V_R = 100 Vdc) (V_R = 50 Vdc) (V_R = 50 Vdc, T_A = 125°C)	2	I_R	 — — —	 5.0 0.1 20	μAdc
Forward Voltage (I_F = 1 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	1	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Capacitance (V_R = 0)	3	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — FORWARD CHARACTERISTICS

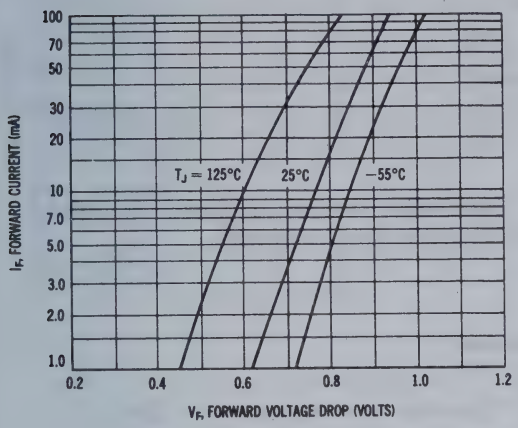


FIGURE 2 — REVERSE LEAKAGE CURRENT

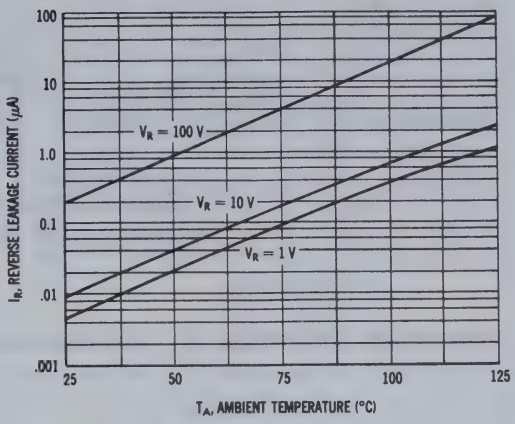


FIGURE 3 — CAPACITANCE

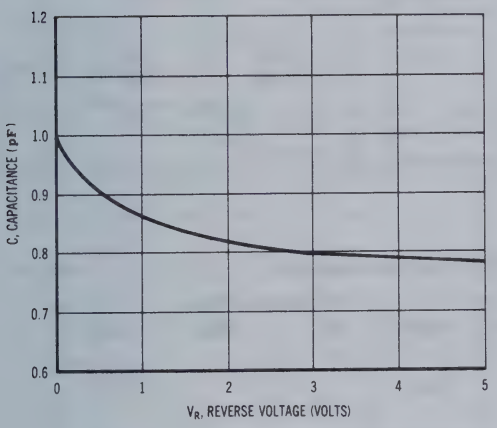


FIGURE 4 — REVERSE RECOVERY TIME

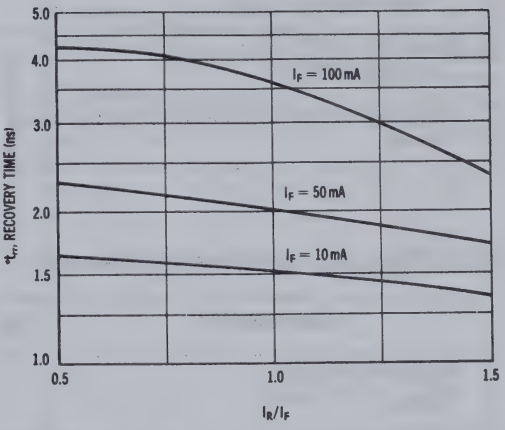
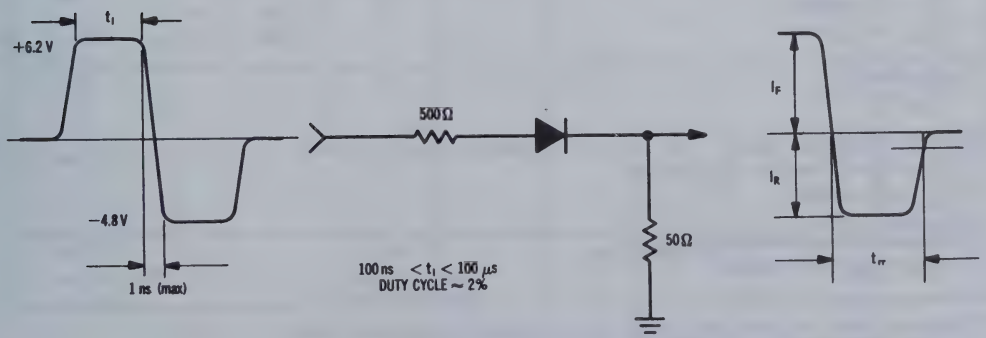


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6101 (SILICON)



CASE 29(3)
(TO-92)



PIN 1. ANODE
2. ANODE
3. CATHODE



Silicon epitaxial dual discriminator diode designed for use in FM discriminator applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	-	$V_{(BR)}$	50	-	Vdc
Reverse Current (V_R = 40 Vdc) (V_R = 40 Vdc, T_A = 125°C)	2	I_R	- -	0.1 100	μAdc
Forward Voltage (I_F = 0.1 mAdc) (I_F = 10 mAdc)	1	V_F	0.43 0.67	0.57 0.82	Vdc
Capacitance (V_R = 0)	3	C	-	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4, 5	t_{rr}	-	10	ns
Forward Voltage Matching $\lvert V_{F1} - V_{F2} \rvert$ (I_{F1} = I_{F2} = 0.1 mAdc)	-	ΔV_F	-	0.003	Vdc

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — FORWARD CHARACTERISTICS

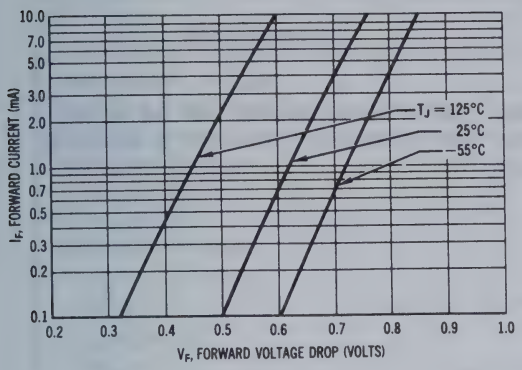


FIGURE 2 — REVERSE LEAKAGE CURRENT

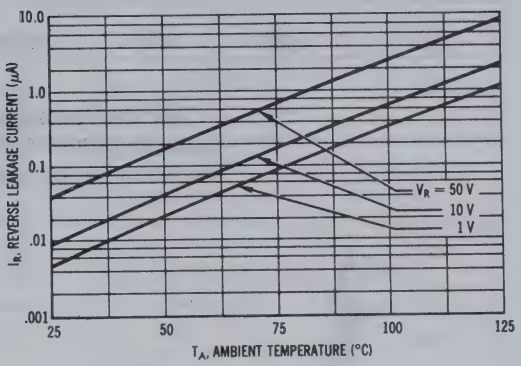


FIGURE 3 — CAPACITANCE

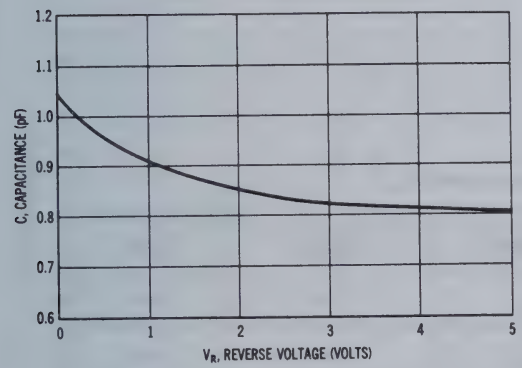


FIGURE 4 — REVERSE RECOVERY TIME

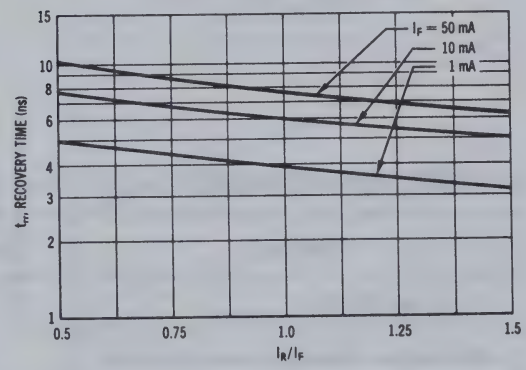
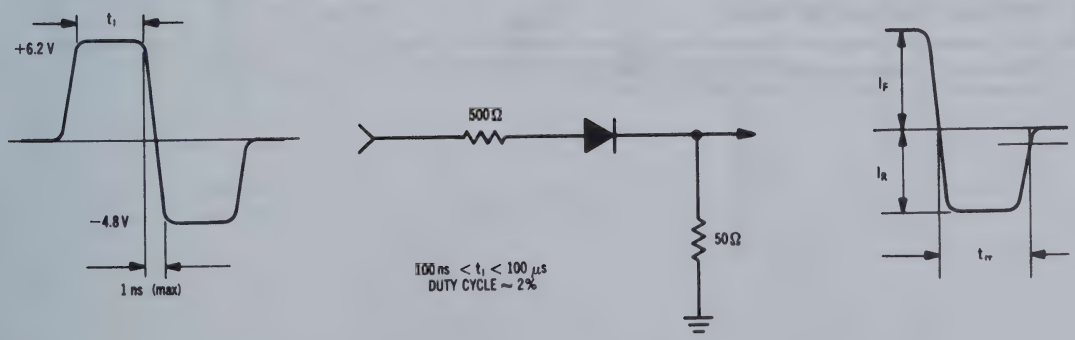


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6102 (SILICON)

Silicon epitaxial dual diode designed for use as a horizontal phase detector for television receivers, and for similar applications.



CASE 29(3)
(TO-92)



PIN 1. ANODE
2. ANODE
3. CATHODE



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	135	°C
Storage Temperature Range	T_{stg} (1)	-55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	0.67	1.0	Vdc
Capacitance (V_R = 0)	C	—	3.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	100	ns

FIGURE 1 — FORWARD CHARACTERISTICS

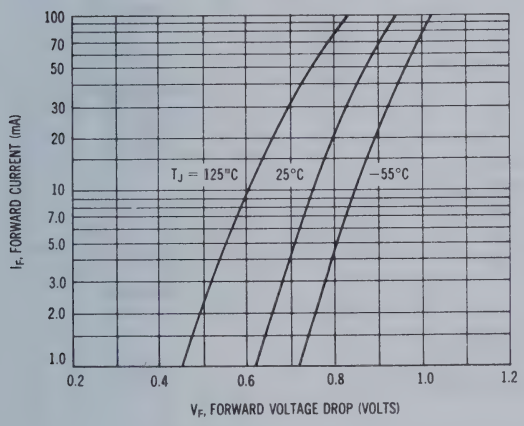


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

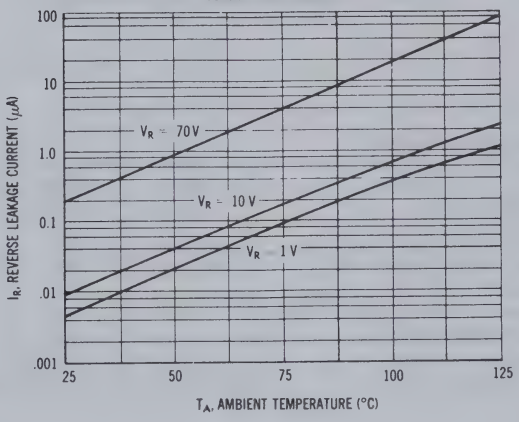
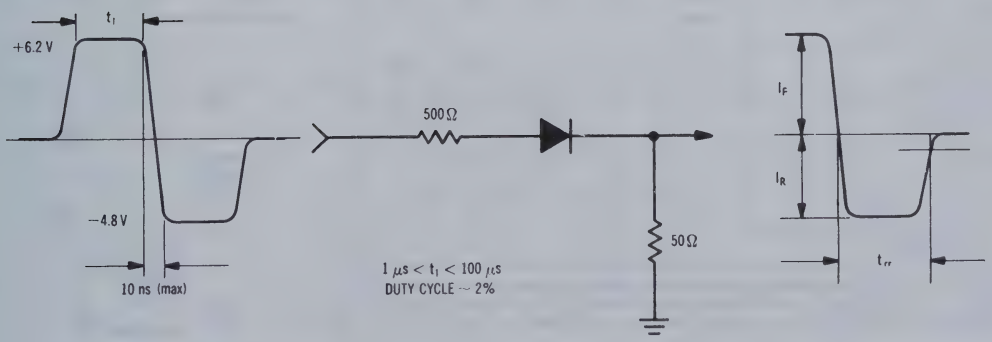


FIGURE 3 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6150 (SILICON)

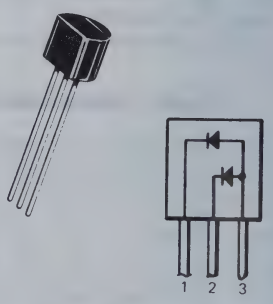
SILICON EPITAXIAL DUAL DIODE

. . . designed for general-purpose consumer applications.

- High Breakdown Voltage –
  $V_{(BR)}$ = 70 Vdc (Min) @ $I_{(BR)}$ = 100 μAdc
- Space-Saving Package with Common Anode Configuration
- One-Piece, Injection-Molded Unibloc Package

SILICON EPITAXIAL DUAL DIODE

COMMON ANODE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	–	–	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	–	–	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	–	0.80	1.0	Vdc
Capacitance (V_R = 0)	C	–	5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	–	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_A = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = -55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.

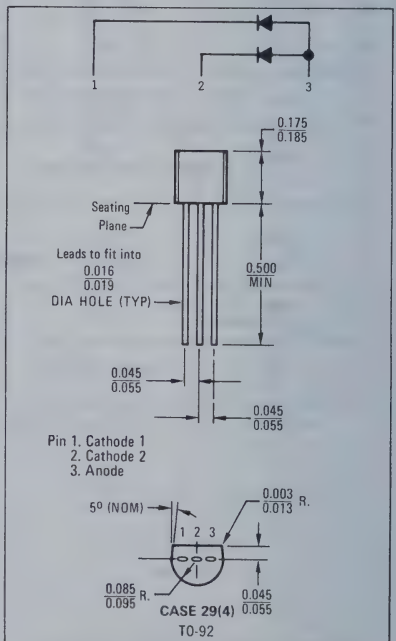


FIGURE 1 – FORWARD CHARACTERISTICS

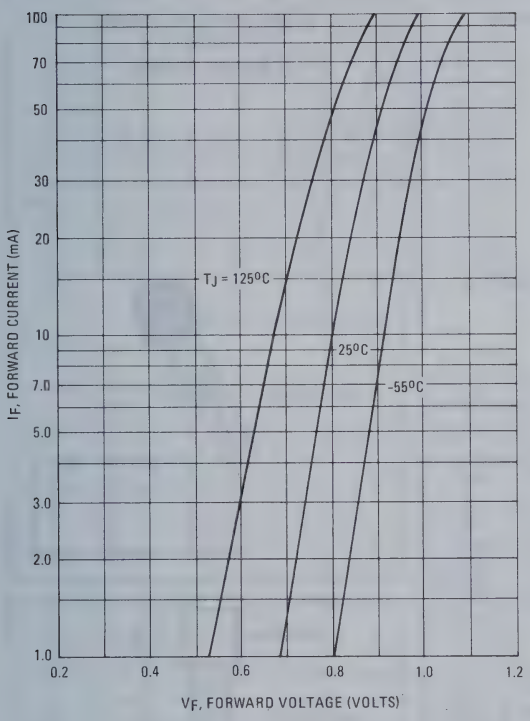


FIGURE 2 – REVERSE LEAKAGE CURRENT

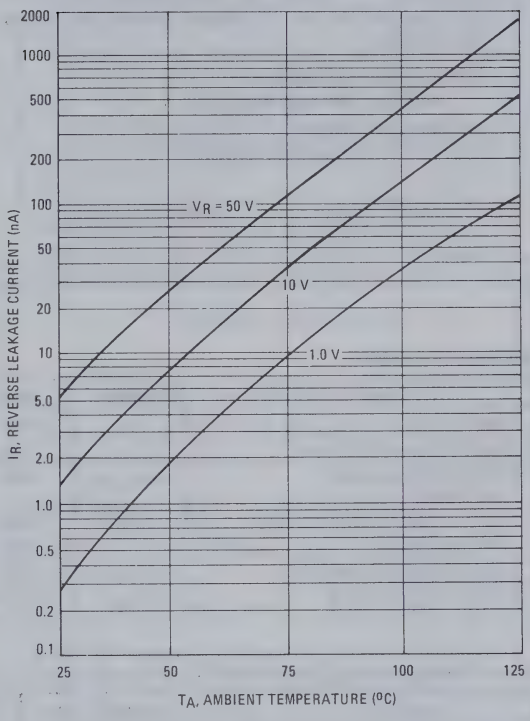
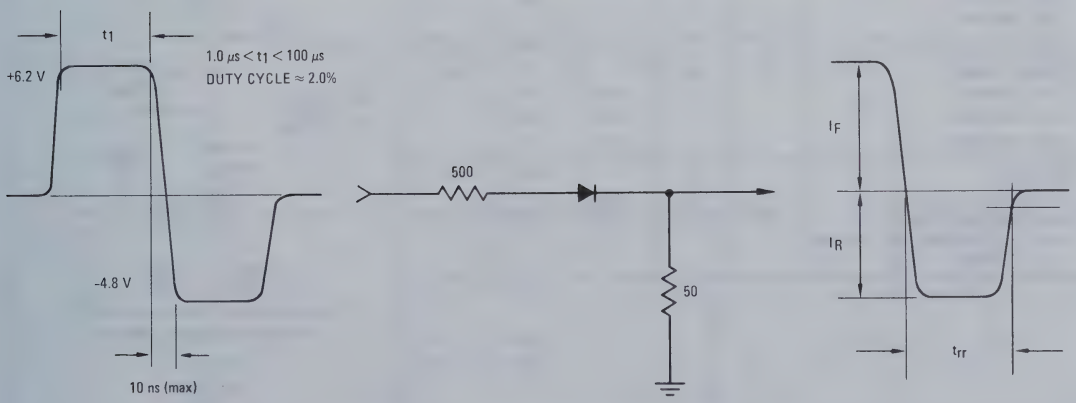


FIGURE 3 – RECOVERY TIME EQUIVALENT TEST CIRCUIT



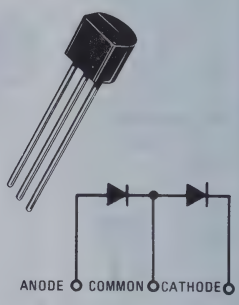
MSD7000 (SILICON)

SILICON EPITAXIAL DUAL SERIES DIODE

. . . designed for use in biasing, steering and voltage doubler applications.

- High Breakdown Voltage —
  $V_{(BR)}$ = 100 Volts minimum
- Low Capacitance —
  C = 1.5 pF maximum @ V_R = 0

SILICON EPITAXIAL DUAL SERIES DIODE

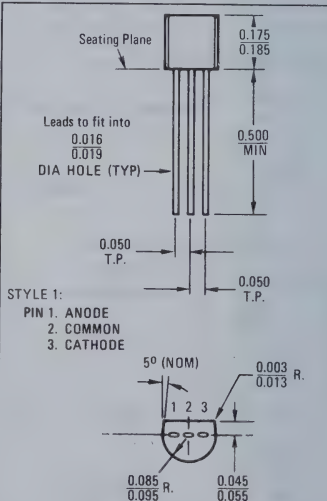


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.82	mW mW/°C
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	–	$V_{(BR)}$	100	–	Vdc
Reverse Current	2	I_R			μAdc
(V_R = 100 Vdc)			–	0.5	
(V_R = 50 Vdc)			–	0.2	
(V_R = 50 Vdc, T_A = 125°C)			–	100	
Forward Voltage	1	V_F			Vdc
(I_F = 1.0 mAdc)			0.55	0.7	
(I_F = 10 mAdc)			0.67	0.82	
(I_F = 100 mAdc)			0.75	1.1	
Capacitance (V_R = 0)	3	C	–	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	–	15	ns



To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

FIGURE 1 – FORWARD CHARACTERISTICS

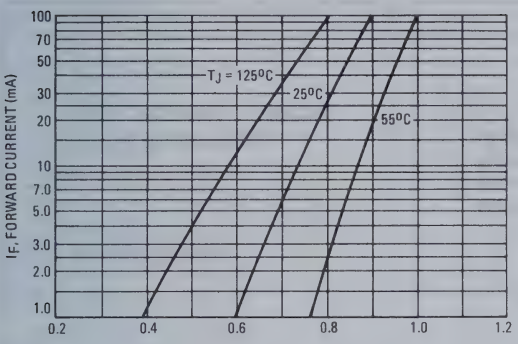


FIGURE 2 – REVERSE LEAKAGE CURRENT

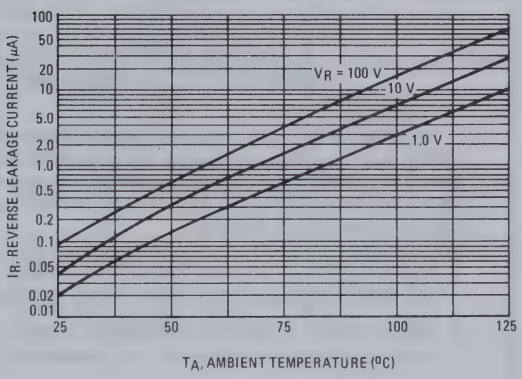


FIGURE 3 – CAPACITANCE

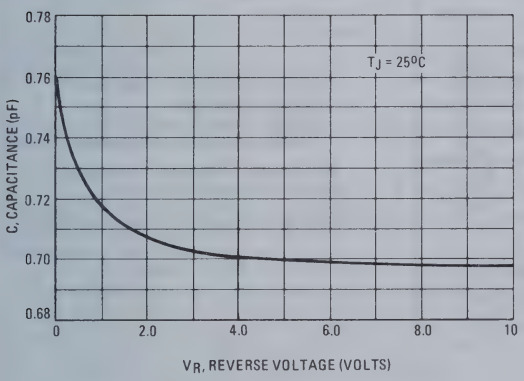


FIGURE 4 – REVERSE RECOVERY TIME

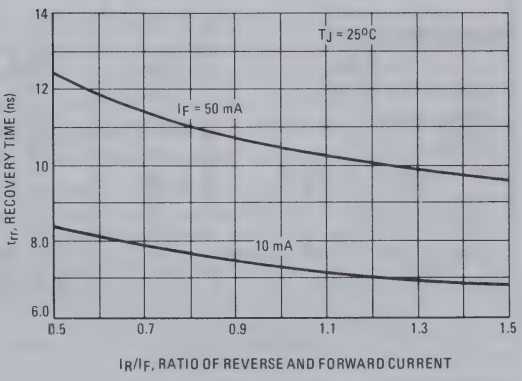
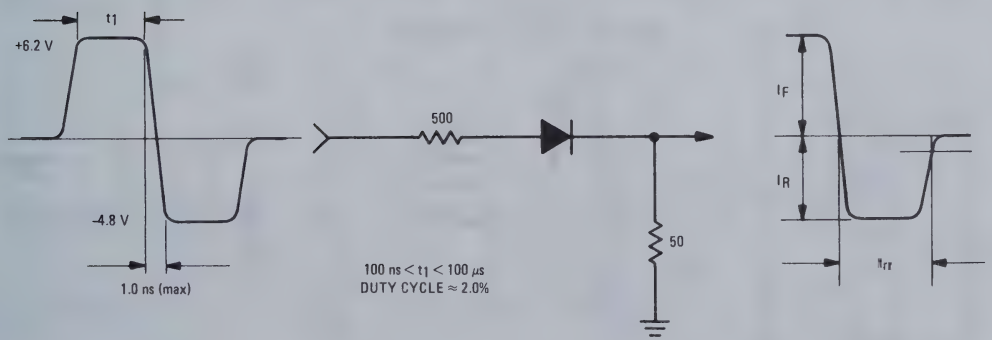


FIGURE 5 – RECOVERY TIME EQUIVALENT TEST CIRCUIT



MU851 (SILICON)
thru
MU853

SILICON ANNULAR UNIJUNCTION TRANSISTORS

. . . designed for computer and industrial applications requiring high-density mounting. These devices are used in pulse, timing, triggering, sensing and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents, as well as outstanding reliability and uniformity.

- Low Peak-Point Current – I_P = 0.4 μA Max (MU853)
- Low Emitter Reverse Current – I_{EO} = 50 nA Max (MU853)
- Fast Switching – 1.0 MHz Min Oscillation Frequency
- Electrically Similar to The 2N4851 Thru 2N4853 Devices

MICRO-T UNIJUNCTION TRANSISTORS



UNIT IDENTITY COLOR CODING
MU851 – Red Plastic
MU852 – Black on Red Plastic
MU853 – Yellow on Red Plastic

For Handling Convenience, All Devices are Painted White on the Bottom.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage (1)	V_{B2B1}	28	Volts
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current (2)	i_e	1.5	Amp
RMS Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Based Upon Power Dissipation at T_A = 25°C
(2) Duty Cycle ≦ 1.0%, PRR = 10 pps (See Figure 6)

FIGURE 1 – UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

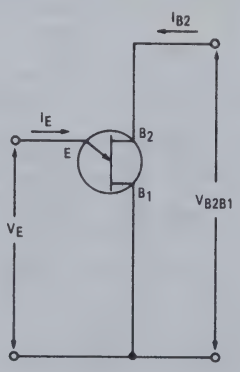
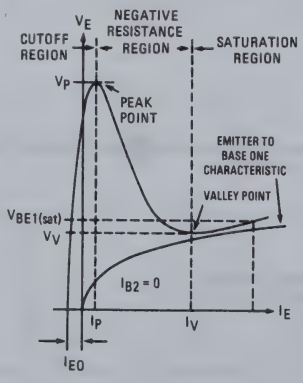
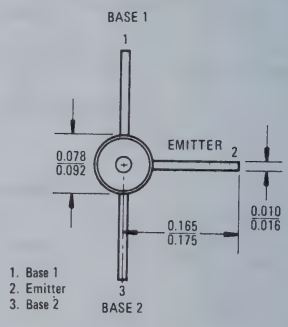


FIGURE 2 – STATIC EMITTER CHARACTERISTICS CURVES





CASE 28 (7)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (1), Figure 3 (V_{B2B1} = 10 V)	MU851	η	0.56	–	0.75	–
	MU852, MU853		0.70	–	0.85	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		R_{BB}	4.7	–	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		αR_{BB}	0.2	–	0.8	%/°C
Emitter Saturation Voltage (2) (V_{B2B1} = 10 V, I_E = 50 mA)		$V_{EB1(sat)}$	–	2.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	–	20	–	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	MU851, MU852	I_{EB2O}	–	–	0.1	μA
	MU853		–	–	0.05	
Peak-Point Emitter Current (V_{B2B1} = 25 V)	MU851, MU852	I_P	–	–	2.0	μA
	MU853		–	–	0.4	
Valley-Point Current (2) (V_{B2B1} = 20 V, R_{B2} = 100 ohms)	MU851	I_V	2.0	–	–	mA
	MU852, MU853		4.0	–	–	
Base-One Peak Pulse Voltage, Figure 4	MU851	V_{OB1}	3.0	–	–	Volts
	MU852		5.0	–	–	
	MU853		6.0	–	–	
Maximum Frequency of Oscillation, Figure 5		$f_{(max)}$	1.0	1.25	–	MHz

(1) η, Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 3. Components R1, C1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D1 compensates for V_F. To use, the "cal" button is pushed, and R3 is adjusted to make the current meter, M1, read full scale. When the "Cal" bottom is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

(2) Use pulse techniques: PW ≈ 300 μs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 – η TEST CIRCUIT

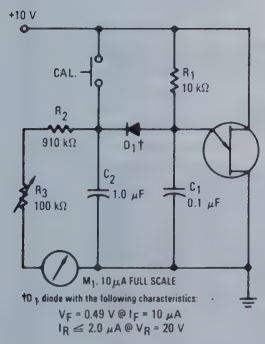


FIGURE 4 – V_{OB1} TEST CIRCUIT

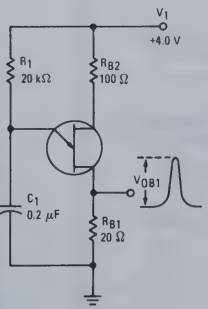


FIGURE 5 – $f_{(max)}$ TEST CIRCUIT

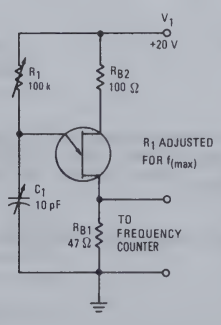
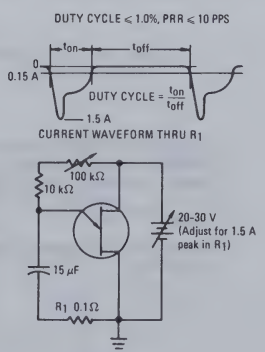


FIGURE 6 – PRR TEST CIRCUIT AND WAVEFORM



MU4891 (SILICON)
thru
MU4894

SILICON ANNULAR PLASTIC UNIJUNCTION TRANSISTORS

. . . designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.

Recommended usage includes:

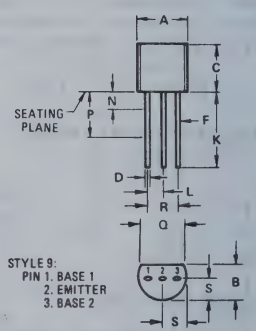
- Long-time Delay Circuits - MU4894
- Silicon Controlled Rectifier Triggering Circuits - MU4893
- High-frequency Relaxation-Oscillator Circuits - MU4892
- General-Purpose Unijunction Applications - MU4891

PN UNIJUNCTION TRANSISTORS



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	300	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +150	°C



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

* Derate 3.0 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation,

$V_{B2B1} = \sqrt{R_{BB} \cdot P_D}$

** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	MU4892	η	0.51	-	0.69	-
	MU4891, MU4893		0.55	-	0.82	
	MU4894		0.74	-	0.86	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	MU4891, MU4892	r_{BB}	4.0	7.0	9.1	k ohms
	MU4893, MU4894		4.0	7.0	12.0	
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to + 100°C)		αr_{BB}	0.1	-	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2		$V_{EB1(sat)}$	-	2.5	4.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	10	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}	-	5.0	10	nA
Peak Point Emitter Current (V_{B2B1} = 25 V)	MU4891	I_P		0.6	5.0	μA
	MU4892, MU4893		-	0.6	2.0	
	MU4894		-	0.6	1.0	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	MU4891, MU4893, MU4894	I_V	2.0	4.0	-	mA
	MU4892		2.0	3.0	-	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	MU4891, MU4892, MU4894	V_{OB1}	3.0	5.0	-	Volts
	MU4893		6.0	8.0	-	

NOTES

1. Intrinsic standoff ratio.
   η is defined by equation:
   $$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$
   Where V_P = Peak Point Emitter Voltage
   V_{B2B1} = Interbase Voltage
   $V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (~0.5 V @ 10 μA)

2. Use pulse techniques: PW = 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

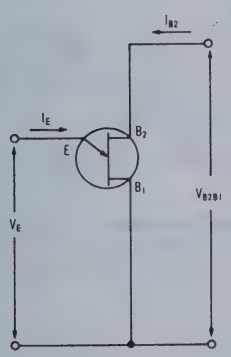


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

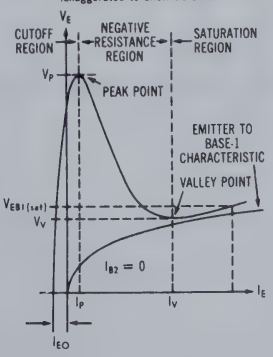
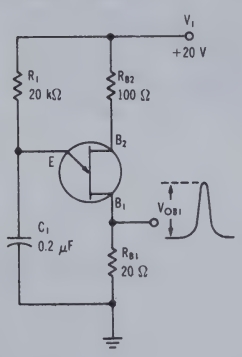


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)



MUS4987 (SILICON)
MUS4988



SILICON UNIDIRECTIONAL SWITCH

. . . designed for half-wave triggering in SCR phase control circuits, bi-stable memory elements and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.5 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02%/°C Typical

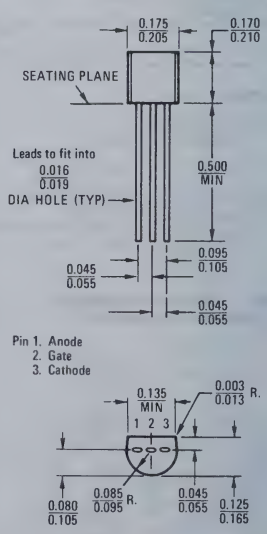
SILICON UNIDIRECTIONAL SWITCH (PLASTIC)

6.0–10 VOLTS
300 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate above $T_A = 25^oC$	P_D	300 3.0	mW mW/°C
Peak Reverse Voltage	V_R	30	Vdc
DC Forward Anode Current Derate above $T_A = 25^oC$	I_F	200 2.0	mA mA/°C
DC Gate Current (off-state only)	$I_G(off)$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, $T_A = 100^oC$)	$I_{FM}(rep)$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, $T_A = 25^oC$	$I_{FM}(nonrep)$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



To convert inches to millimeters multiply by 25.4.

CASE 29-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage		V_S				Vdc
	MUS4987		6.0	8.0	10	
	MUS4988		7.5	8.0	9.0	
Switching Current		I_S				μAdc
	MUS4987		–	110	500	
	MUS4988		–	80	150	
Reverse Current		I_R				μAdc
(V_R = 30 V, T_A = 25°C)	MUS4987		–	–	0.1	
(V_R = 30 V, T_A = 85°C)	MUS4987		–	–	1.0	
(V_R = 30 V, T_A = 25°C)	MUS4988		–	–	0.1	
(V_R = 30 V, T_A = 100°C)	MUS4988		–	–	1.0	
Holding Current		I_H				mAdc
	MUS4987		–	0.14	1.5	
	MUS4988		–	0.11	0.5	
Forward Blocking Current		I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)	MUS4987		–	–	0.1	
(V_F = 5.0 Vdc, T_A = 85°C)	MUS4987		–	–	1.0	
(V_F = 5.0 Vdc, T_A = 25°C)	MUS4988		–	–	0.1	
(V_F = 5.0 Vdc, T_A = 100°C)	MUS4988		–	–	1.0	
Forward On-State Voltage (I_F = 150 mAdc)		V_F	–	1.32	1.5	Vdc
Peak Output Voltage (C_C = 0.1 μF, R_L = 20 ohms, Figure 9)		V_O	3.5	4.6	–	Vdc
Turn-On Time (Figure 10)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 11)		t_{off}	–	25	–	μs
Temperature Coefficient of Switching Voltage		TC	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE

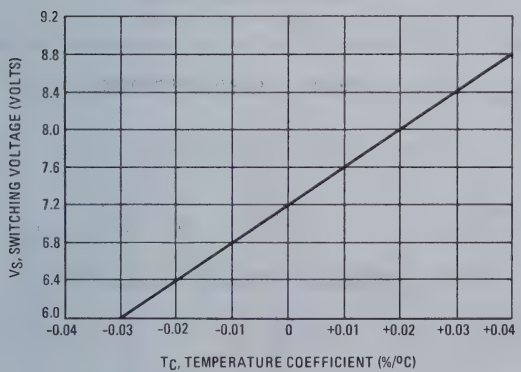


FIGURE 2 – SWITCHING CURRENT

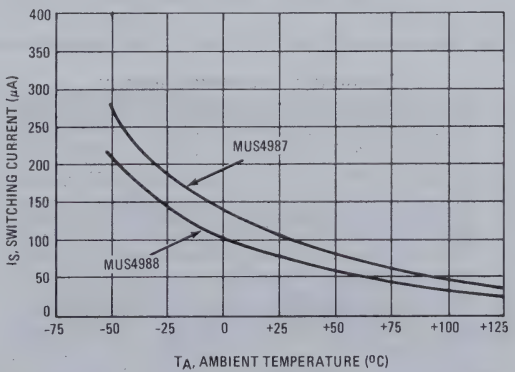


FIGURE 3 – HOLDING CURRENT

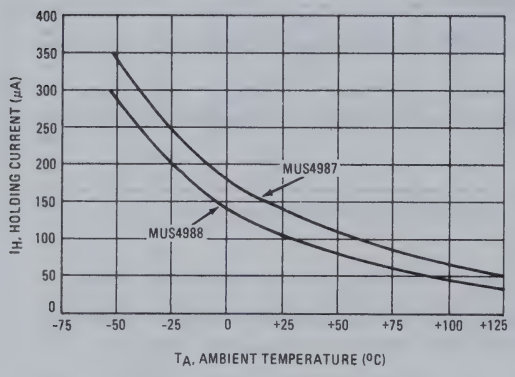


FIGURE 4 – FORWARD BLOCKING CURRENT

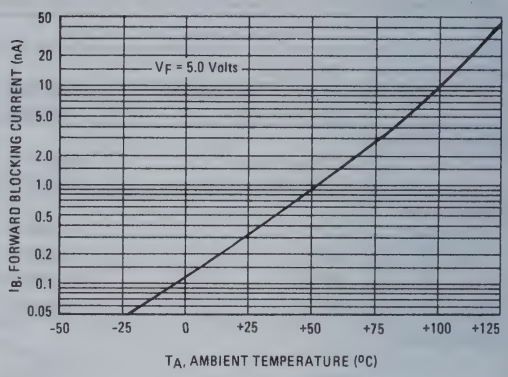


FIGURE 5 – FORWARD ON-STATE VOLTAGE

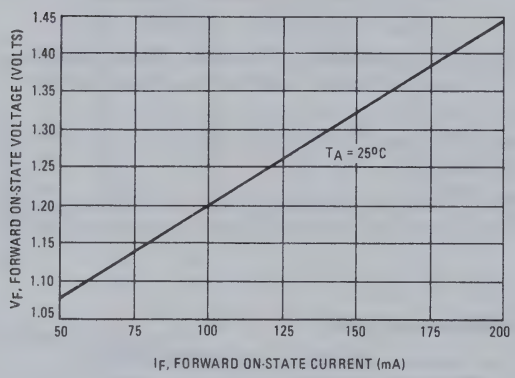


FIGURE 6 – OUTPUT VOLTAGE (FUNCTION OF R_L AND C_C)

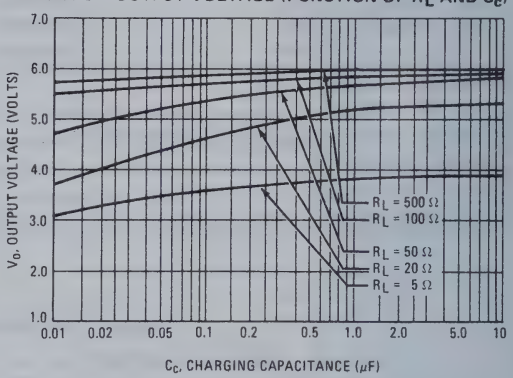


FIGURE 7 – REVERSE CURRENT

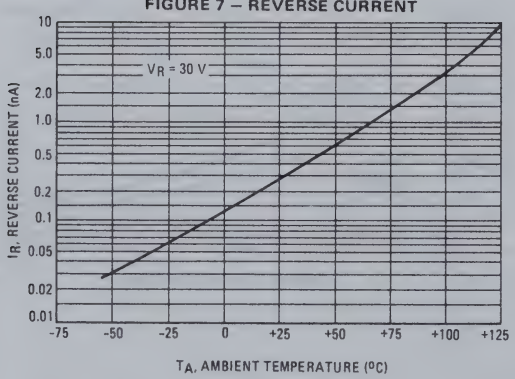
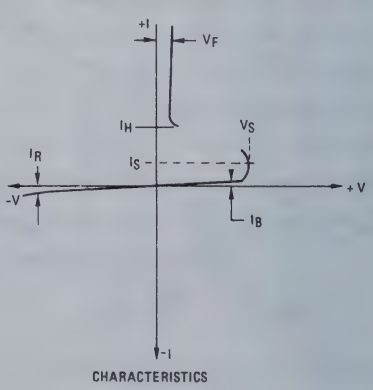


FIGURE 8 – CHARACTERISTICS



CHARACTERISTICS

FIGURE 9 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

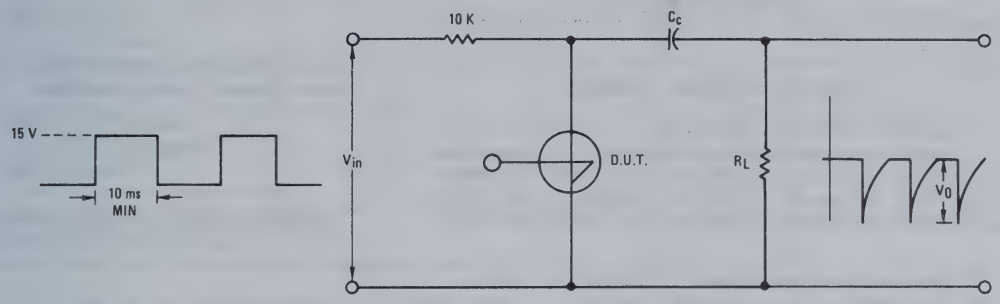
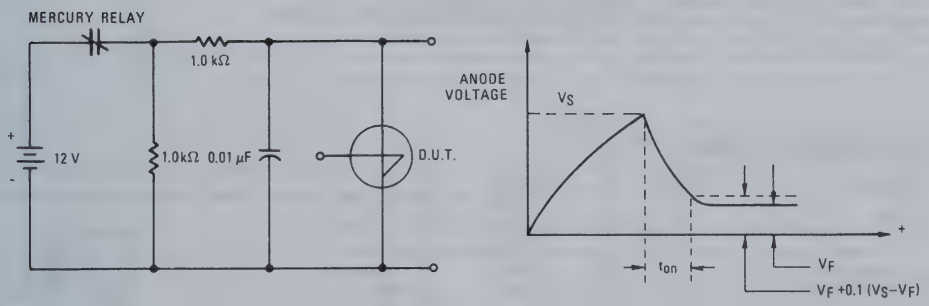
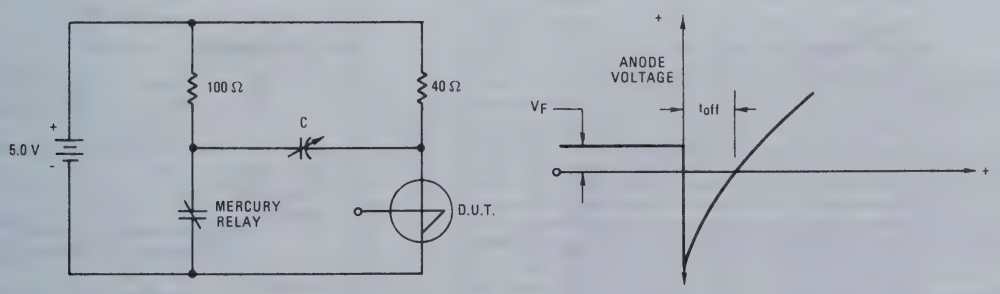


FIGURE 10 – TURN-ON TIME TEST CIRCUIT



Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 11 – TURN-OFF TIME TEST CIRCUIT



With the SUS in conduction and the relay contacts open, the contacts are closed and the anode is driven negative. C is decreased, and when the anode voltage becomes positive, the SUS remains off. The turn-off time, t_{off}, is the time between initial contact closure and the point where the anode voltage passes through zero volts.

MV104 (SILICON)

VVC

SILICON EPICAP DIODES

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configurations for minimum signal distortion and detuning. This device is supplied in the popular TO-92 plastic package for high volume, economical requirements of consumer and industrial applications.

- Guaranteed Capacitance Range — 37-42 pF @ V_R = 3.0 Vdc
- Dual Diodes — Save Space and Reduce Cost
- TO-92 Package for Easy Handling and Mounting
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group
- Monolithic Chip Provides Near Perfect Matching — Guaranteed ±1% (Max) Over Specified Tuning Range.

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±1.5% or 0.1 pF (whichever is greater) over the specified tuning range.

DUAL VOLTAGE-VARIABLE CAPACITANCE DIODES

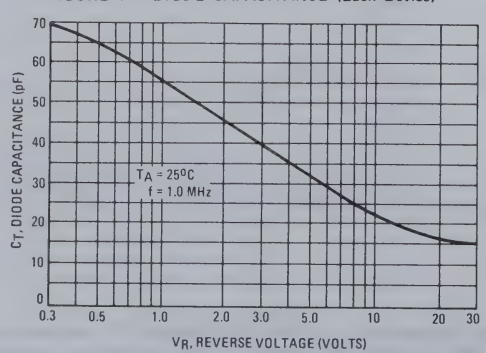
37–42 pF
32 VOLTS

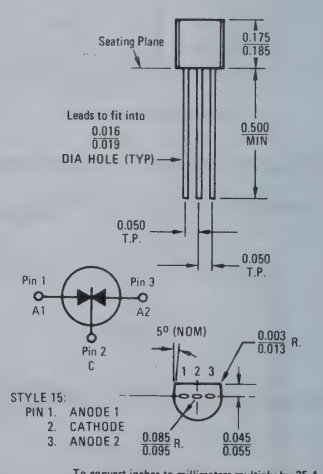


MAXIMUM RATINGS (Each Device)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	32	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 — DIODE CAPACITANCE (Each Device)





To convert inches to millimeters multiply by 25.4

All JEDEC dimensions and notes apply

CASE 29-01
TO-92
PLASTIC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, Each Device)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	32	–	–	Vdc
Reverse Voltage Leakage Current T_A = 25°C (V_R = 30 Vdc) T_A = 60°C	I_R	– –	– –	50 500	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF		Q, Figure of Merit V_R = 3.0 Vdc f = 100 MHz	C_R, Capacitance Ratio C_3/C_{30} f = 1.0 MHz	
Device	Min	Max	Min	Min	Max
MV104	37	42	100	2.5	2.8

TYPICAL CHARACTERISTICS (Each Device)

FIGURE 2 – FIGURE OF MERIT

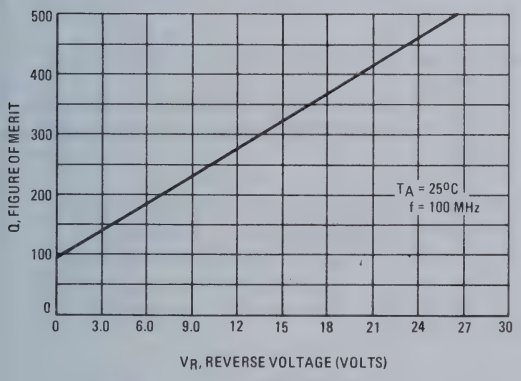


FIGURE 3 – FIGURE OF MERIT

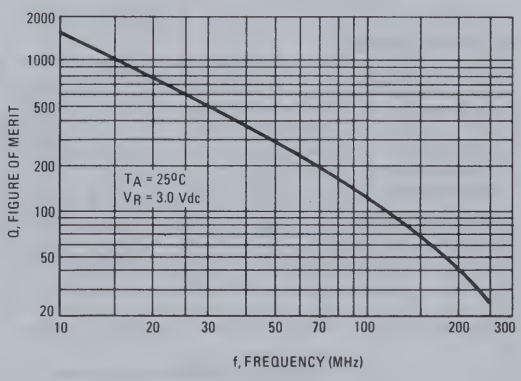


FIGURE 4 – DIODE CAPACITANCE

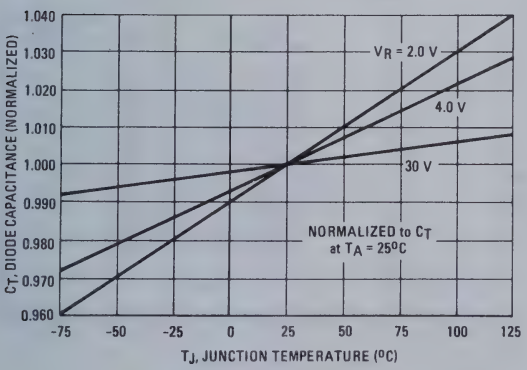
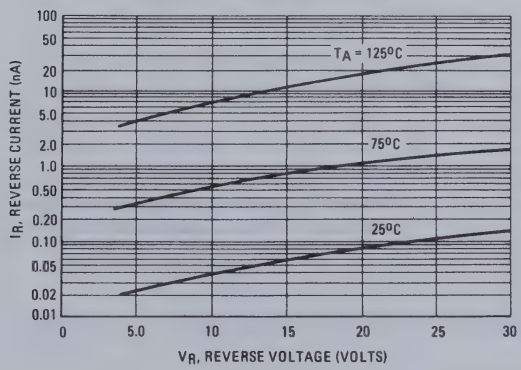


FIGURE 5 – REVERSE CURRENT



MV109 (SILICON)

VVC

SILICON EPICAP DIODE

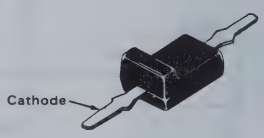
. . . designed in the new low-inductance Mini-L package for high volume requirements in VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Low Inductance Mini-L Package
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±3% or 0.1 pF (whichever is greater) along the entire specified tuning range.

VOLTAGE VARIABLE CAPACITANCE DIODE

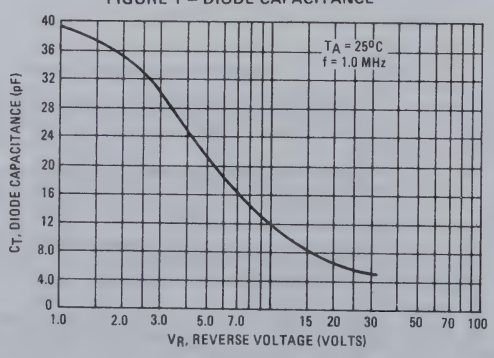
26-32 pF

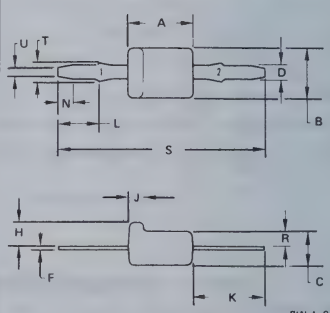


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – DIODE CAPACITANCE





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

PIN 1. CATHODE
2. ANODE

CASE 226

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 28 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1		pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz		Package Stripe
Device	Min	Nom	Max	Min	Min	Max	Color
MV109	26	29	32	280	5.0	6.5	RED

FIGURE 2 – FIGURE OF MERIT

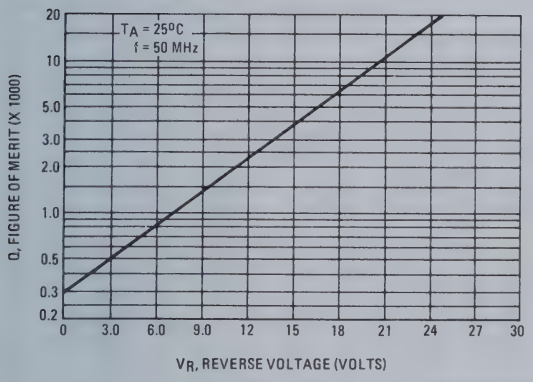


FIGURE 3 – LEAKAGE CURRENT

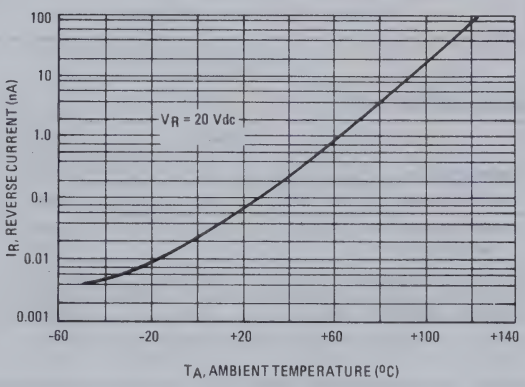
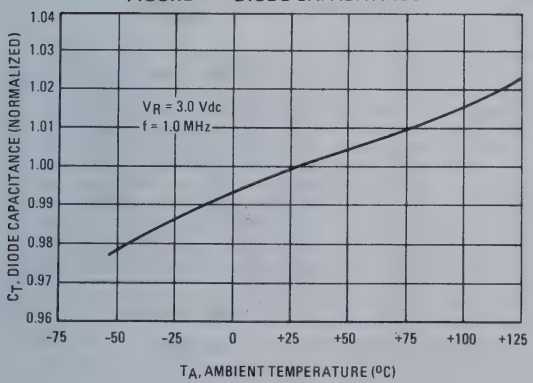


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV209 (SILICON)

VVC

SILICON EPICAP DIODE

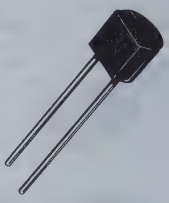
. . . designed for VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching(1) Tolerance From Diode to Diode and Group to Group
- Supplied, in One-Piece, Unibloc Package for High Reliability.

(1) Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±3% or 0.1 pF (whichever is greater) along the entire specified tuning range.

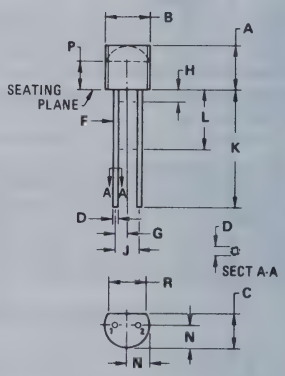
VOLTAGE VARIABLE CAPACITANCE DIODE

26-32 pF



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



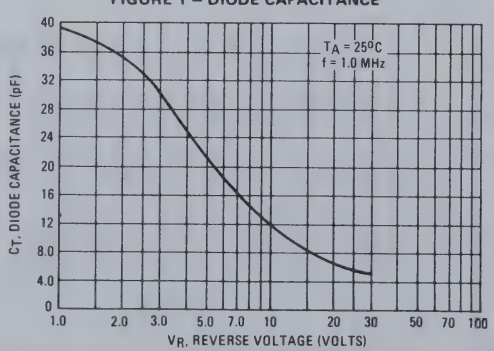
STYLE 2:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

All JEDEC dimensions and notes apply.

CASE 182-02

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μAdc
Series Inductance (Note 1) (f = 250 MHz, Lead Length ≈ 1/8")	L_S	–	6.0	–	nH
Case Capacitance (Note 2) (f = 1.0 MHz)	C_C	–	0.2	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_t, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz (Note 3)	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz (Note 4)	
Device	Min	Nom	Max	Min	Min	Max
MV209	26	29	32	200	5.0	6.5

FIGURE 2 – FIGURE OF MERIT

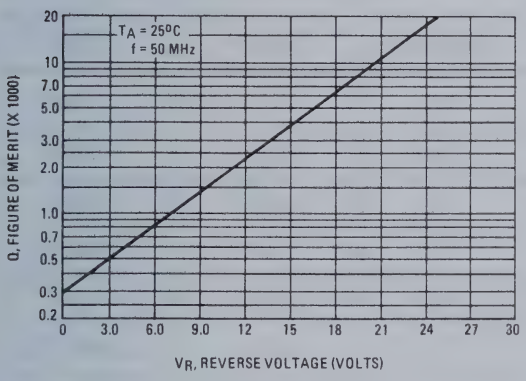


FIGURE 3 – LEAKAGE CURRENT

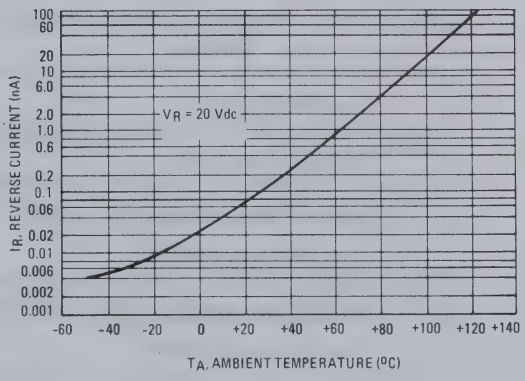
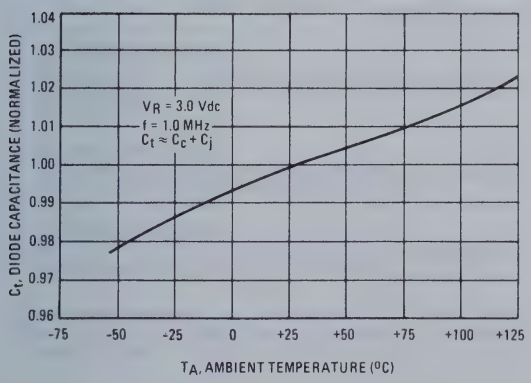


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_t measured at 3.0 Vdc divided by C_t measured at 25 Vdc.

MV830 thru MV840 (SILICON)



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable capacitance diodes, designed for electronic-tuning applications from 15 to 100 pF.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	W mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) See Notes

Characteristic — All Types	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	30	—	—	Vdc
Reverse Voltage Leakage Current	I_R	V_R = 25 Vdc	—	—	0.2	μAdc
Series Inductance	L_S	f = 250 MHz, L ≈ 1/16"	—	5	10	nH
Case Capacitance	C_C	f = 1 MHz, L = 0	—	0.25	0.3	pF

Device	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			TR, Tuning Ratio f = 1 MHz C_4/C_{25}		Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz		α	
	Min	Typ	Max	Min	Typ	Min	Typ	Min	Typ
MV830	13.5	15.0	16.5	1.8	2.00	30	35	0.32	0.375
MV831	16.2	18.0	19.8	1.8	2.00	25	30	0.32	0.375
MV832	19.8	22.0	24.2	1.8	2.10	25	30	0.32	0.40
MV833	24.3	27.0	29.7	1.8	2.10	25	30	0.32	0.40
MV834	29.7	33.0	36.3	1.9	2.12	20	25	0.35	0.41
MV835	35.1	39.0	42.9	1.9	2.12	20	25	0.35	0.41
MV836	42.3	47.0	51.7	1.9	2.15	15	20	0.35	0.415
MV837	50.4	56.0	61.6	1.9	2.15	15	20	0.35	0.415
MV838	61.2	68.0	74.8	2.0	2.18	15	20	0.375	0.425
MV839	73.8	82.0	90.2	2.0	2.18	10	15	0.375	0.425
MV840	90.0	100.0	110.0	2.0	2.18	10	15	0.375	0.425

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1 MHz using a capacitance bridge (Boonton Electronics Model 75A).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1 MHz using a capacitance bridge (Boonton Electronics Model 33AS8).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 4 Vdc divided by C_T measured at 25 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE
The diode capacitance, C_T (as measured at V_R = 4 Vdc, f = 1 MHz) is compared to C_T (as measured at V_R = 30 Vdc, f = 1 MHz) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(30)}{\log 30 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V^{\alpha}}$$

MV1401, MV1403 (SILICON)
MV1404, MV1405

VVC

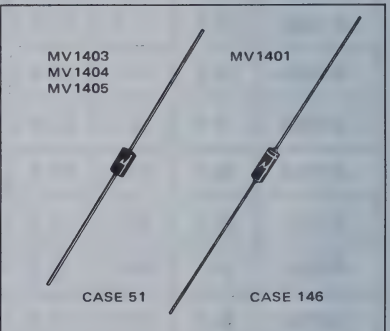
SILICON HYPER-ABRUPT JUNCTION TUNING DIODES

. . . designed with a capacitance change of greater than TEN TIMES for a bias change ranging from 2 to 10 volts. Provides tuning over broad frequency ranges, tuning AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

- High Q with Guaranteed Minimum Values
- Broad Capacitance Selection from 120-550 pF (Nominal Values)
- Available in Two Standard Glass Packages

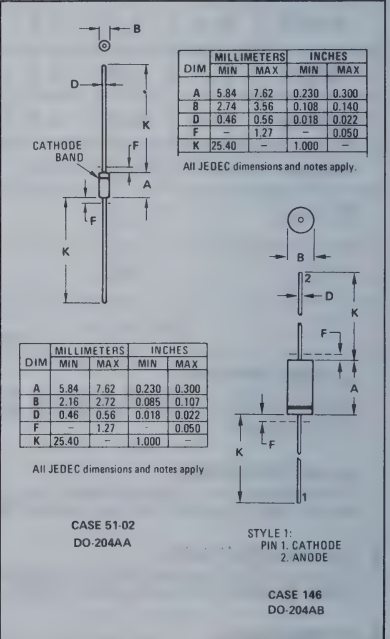
HIGH TUNING RATIO VOLTAGE – VARIABLE CAPACITANCE DIODES

120-550 pF
12 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.74	3.56	0.108	0.140
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	12	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C)	I_R	–	–	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	5.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.25	–	pF

	C_T, Diode Capacitance						Q, Figure of Merit	TR, Tuning Ratio	
	V_R = 1.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz	C_1/C_{10} f = 1.0 MHz	C_2/C_{10} f = 1.0 MHz
Device	Min	Nom	Max	Min	Nom	Max	Min	Min	Min
MV1401	468	550	633	–	–	–	200	14	–
MV1403	–	–	–	140	175	210	200	–	10
MV1404	–	–	–	96	120	144	200	–	10
MV1405	–	–	–	200	250	300	200	–	10

PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. **C_C, CASE CAPACITANCE**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. **C_T, DIODE CAPACITANCE**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

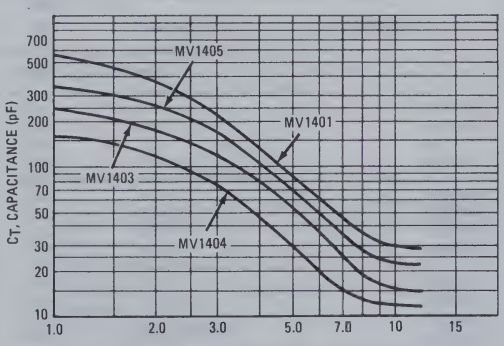
4. **TR, TUNING RATIO**
   TR is the ratio of C_T measured at 2.0 Vdc (1.0 Vdc for MV1401) divided by C_T measured at 10 Vdc.

5. **Q, FIGURE OF MERIT**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equation:

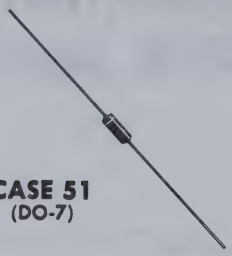
$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE



MV1620 thru MV1650 (SILICON)



CASE 51
(DO-7)

Silicon Epicap diodes, epitaxial passivated tuning diodes designed for AFC applications in radio, TV, and general electronic-tuning.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C	P_D	400	mW
Derate above 25°C		2.67	mW/°C
Device Dissipation @ T_C = 25°C	P_D	2	Watts
Derate above 25°C		13.3	mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic – All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	20	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 15 Vdc	I_R	–	–	0.1	μAdc
Series Inductance	f = 250 MHz, lead length ≈ 1/16"	L_S	–	5.0	10	nH
Case Capacitance	f = 1 MHz, lead length ≈ 1/16"	C_C	–	0.25	0.3	pF

Device	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz	TR, Tuning Ratio * C_2/C_{20} f = 1 MHz	
	Min	Nom	Max	Min	Min	Max
MV1620	6.1	6.8	7.5	300	2.0	3.2
MV1622	7.4	8.2	9.0	300	2.0	3.2
MV1624	9.0	10.0	11.0	300	2.0	3.2
MV1626	10.8	12.0	13.2	300	2.0	3.2
MV1628	13.5	15.0	16.5	250	2.0	3.2
MV1630	16.2	18.0	19.8	250	2.0	3.2
MV1632	18.0	20.0	22.0	250	2.0	3.2
MV1634	19.8	22.0	24.2	250	2.0	3.2
MV1636	24.3	27.0	29.7	200	2.0	3.2
MV1638	29.7	33.0	36.3	200	2.0	3.2
MV1640	35.1	39.0	42.9	200	2.0	3.2
MV1642	42.3	47.0	51.7	200	2.0	3.2
MV1644	50.4	56.0	61.6	150	2.0	3.2
MV1646	61.2	68.0	74.8	150	2.0	3.2
MV1648	73.8	82.0	90.2	150	2.0	3.2
MV1650	90.0	100.0	110.0	150	2.0	3.2

* TR, Tuning Ratio, is the ratio of C_T measured at 2 Vdc divided by C_T measured at 20 Vdc.

MV1652 (SILICON)
MV1654
MV1656
MV1658
MV1660
MV1662
MV1664
MV1666



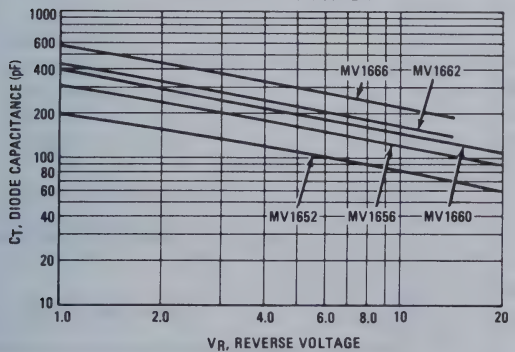
Silicon epicap epitaxial passivated tuning diodes designed for general tuning, trimming and AFC applications at low radio frequencies.

CASE 146

MAXIMUM RATINGS

Rating	Symbol	MV1652 MV1654 MV1656 MV1658 MV1660	MV1662 MV1664 MV1666	Unit
Reverse Voltage	V_R	20	15	Vdc
Forward Current	I_F	400		mAdc
Total Device Dissipation @ T_A = 25°C	P_D	400		mW
Derate above 25°C		2.67		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

FIGURE 1 - DIODE CAPACITANCE versus REVERSE VOLTAGE



PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
   L_S, is determined from the self resonant frequency and the junction capacity of the device.
   $$L_S = \frac{1}{\omega^2_{res} C_J}$$
2. C_T, DIODE CAPACITANCE
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. TR, TUNING RATIO
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 20 Vdc or at 15 Vdc.
4. Q, FIGURE OF MERIT
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:
   $$Q = \frac{2\pi fC}{G}$$
   (Boonton Electronics Model 33AS9 with range extender or equivalent).

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	MV1652 thru MV1660	BV_R	20	-	-	Vdc
	MV1662 thru MV1666		15	-	-	
Reverse Current		I_R				μAdc
(V_R = 15 Vdc)	MV1652 thru MV1660		-	-	0.1	
(V_R = 10 Vdc)	MV1662 thru MV1666		-	-	0.1	
Series Inductance	MV1652 thru MV1666	L_S	-	5.0	-	nH

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz (pF)			Q, Figure of Merit V_R = 4.0 Vdc, f = 20 MHz	Capacitance Ratio C_2/C_{20}
	Min	Nom	Max		Typical
MV1652	108	120	135	250	2.6
MV1654	132	150	165	250	2.6
MV1656	162	180	198	200	2.6
MV1658	180	200	220	200	2.6
MV1660	198	220	242	150	2.6
					C_2/C_{15}
MV1662	225	250	275	150	2.3
MV1664	243	270	300	100	2.3
MV1666	297	330	363	100	2.3

MV1804 (SILICON)

For Specifications, See 1N4387 Data, Volume 1.

MV1805C (SILICON)



CASE 47

High-frequency step-recovery silicon power varactor for 100 MHz to 2.0 GHz harmonic-generation applications with output power up to 35 watts at 1.0 GHz.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	80	Volts
Forward Current	I_F	5.0	Amps
RF Power Input	P_{in}	50	Watts
Total Device Dissipation @ T_A = 75°C	P_D	18	Watts
Derate above 75°C		0.14	W/°C
Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	80	95	—	Vdc
Reverse Current	I_R	V_R = 70 Vdc	—	—	2	μAdc
		V_R = 70 Vdc, T_A = 150°C	—	—	100	
Diode Capacitance	C_T	V_R = 6 Vdc, f = 1.0 MHz	20	25	30	pF
Figure of Merit	Q	V_R = 6 Vdc, f = 50 MHz	—	500	—	—
Thermal Resistance	θ_{JC}		—	—	7	°C/W

FUNCTIONAL TEST

RF Power Output	P_{out}	Test Setup Figure 4 P_{in} = 40 Watts	26	—	—	Watts
Tripler Efficiency	η	f_{in} = 250 MHz f_{out} = 750 MHz	65	—	—	%

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 1A — DOUBLING (X2)

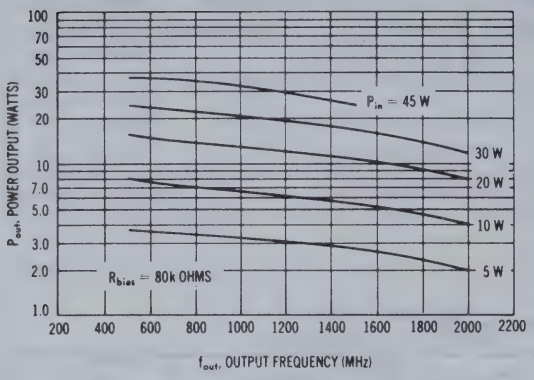


FIGURE 1B — TRIPLING (X3)

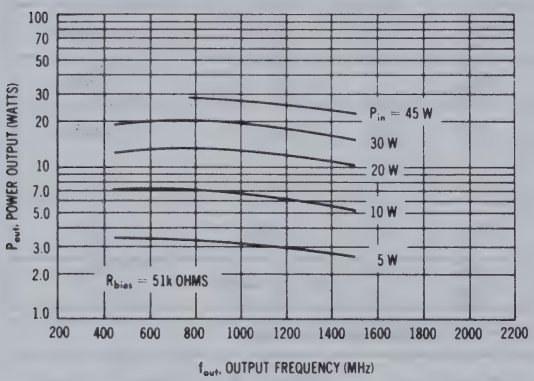


TABLE 1 — TYPICAL QUADRUPLING (X4)

f_{in} = 275 MHz, f_{out} = 1100 MHz, R_{bias} = 100k OHMS

INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	2.6	52
10	5.4	54
20	10.6	53
30	14.4	48
40	19.0	47.5
45	20.6	45.8

TABLE 2 — TYPICAL ONE-STEP (X9)

f_{in} = 50 MHz, f_{out} = 450 MHz, R_{bias} = 5k OHMS

INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	1.4	28
10	2.7	27

FIGURE 2 — TRIPLER LINEARITY CHARACTERISTICS

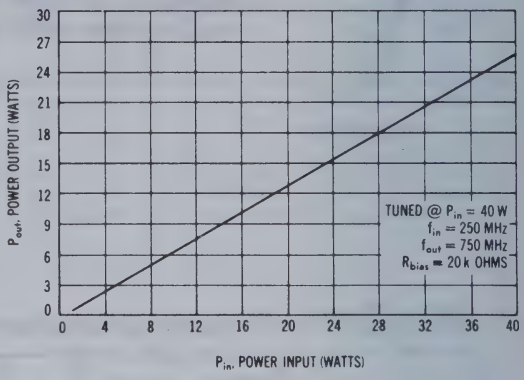


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE

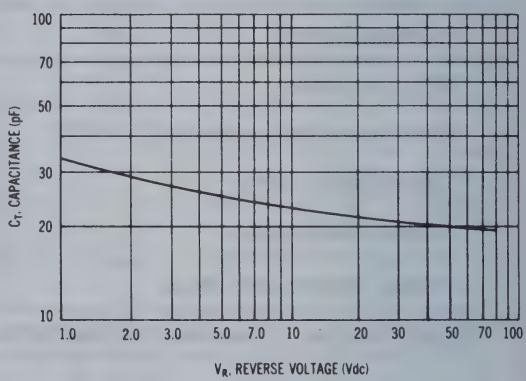
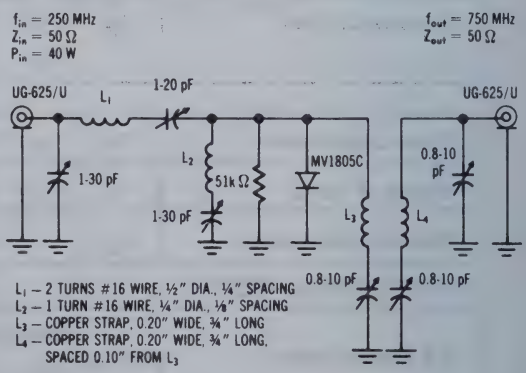


FIGURE 4 — HARMONIC TRIPLER — 250 MHz to 750 MHz



L_1 — 2 TURNS #16 WIRE, ½" DIA., ¼" SPACING
L_2 — 1 TURN #16 WIRE, ¼" DIA., ⅛" SPACING
L_3 — COPPER STRAP, 0.20" WIDE, ¾" LONG
L_4 — COPPER STRAP, 0.20" WIDE, ¾" LONG, SPACED 0.10" FROM L_3

MV1806 (SILICON)

For Specifications, See 1N4388 Data, Volume 1.

MV1806C, MV1807C (SILICON)

For Specifications, See 1N5149 Data.

MV1807C1, MV1808B1, MV1808C1, MV1810B1 (SILICON)

For Specifications, See 1N5150A Data.

MV1808A, MV1808B, MV1808C (SILICON)

For Specifications, See 1N5151 Data.

MV1809C (SILICON)
MV1809C1



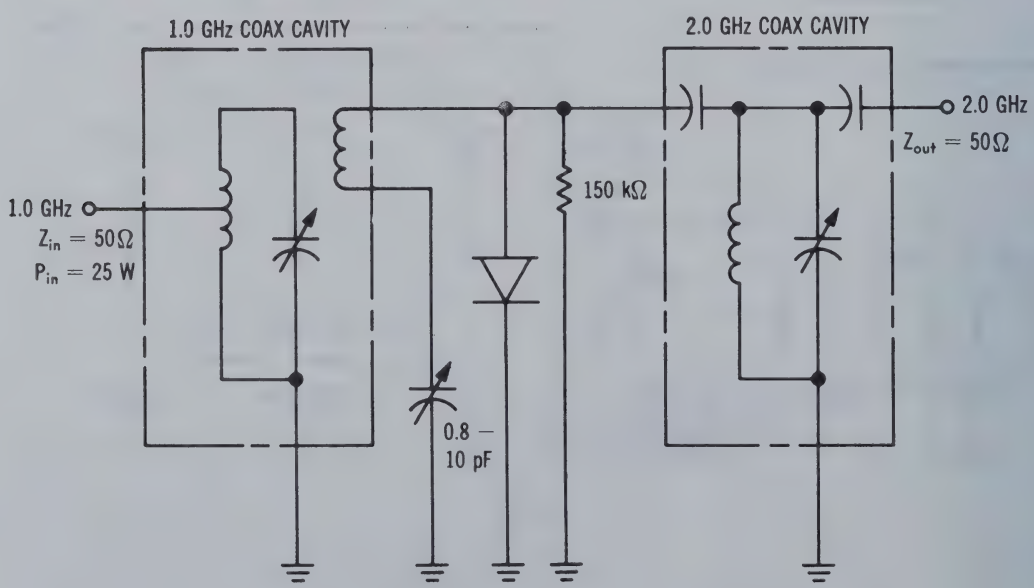
CASE 47

Silicon high-frequency step-recovery power varactors for 300 MHz to 3.0 GHz harmonic-generation applications with output power to 17 watts at 2.0 GHz.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	75	Vdc
Forward Current		I_F	5.0	Adc
RF Power Input	MV1809C MV1809C1	P_{in}	25 30	Watts
Total Device Dissipation @ T_C = 75°C	MV1809C MV1809C1	P_D	9.0 14	Watts
Derate above 75°C	MV1809C MV1809C1		0.07 0.11	mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT



MV1809C, MV1809C1 (continued)

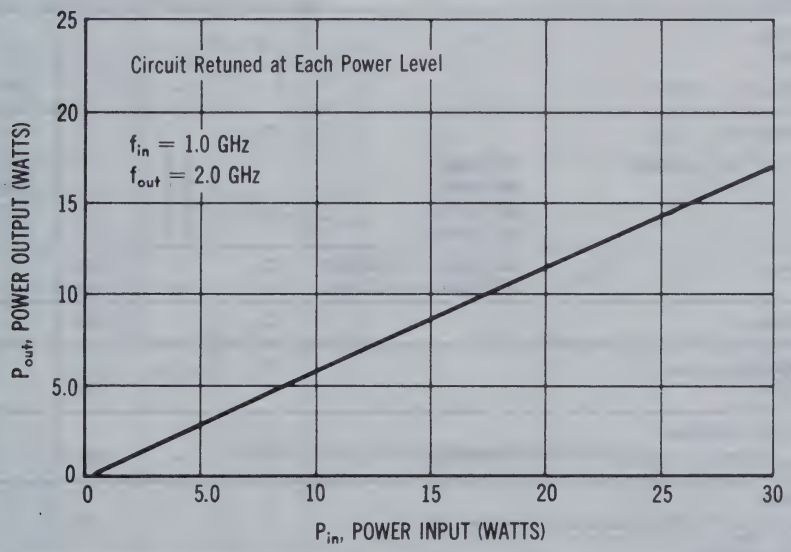
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	75	-	-	Vdc
Reverse Current (V_R = 70 Vdc)		I_R	-	-	2.0	μAdc
(V_R = 70 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance ($C_J + C_C$)	MV1809C	C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1809C		9.6	-	14.4	
	MV1809C1		10.8	-	13.2	
Case Capacitance		C_C	-	0.47	-	pF
Series Inductance		L_S	-	2.2	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.35	0.5	Ohm
Thermal Resistance	MV1809C	θ_{JC}	-	-	14	°C/W
	MV1809C1		-	-	9.0	

FUNCTIONAL TESTS

MV1809C1 Power Output	Doubler Test Circuit (Figure 1) P_{in} = 25 W, f_{in} = 1.0 GHz, f_{out} = 2.0 GHz	P_{out}	14.5	-	-	Watt
Efficiency		η	58	-	-	%
MV1809C Power Output	Doubler Test Circuit (Figure 1) P_{in} = 20 W, f_{in} = 1.0 GHz, f_{out} = 2.0 GHz	P_{out}	10.4	-	-	Watt
Efficiency		η	52	-	-	%

FIGURE 2 — POWER OUTPUT versus POWER INPUT



MV1810A, MV1810B (SILICON)

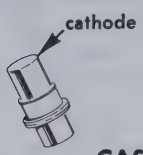
For Specifications, See 1N5154 Data.

MV1812A, M1812B (SILICON)

For Specifications, See 1N5156 Data.

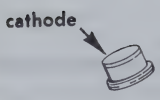
MV1816A, B (SILICON)
MV1816A1, B1

Silicon high-frequency power varactors designed for high efficiency in frequency multiplier applications. Permits ONE-STEP multiplication to frequencies as high as 3.0 GHz.



CASE 46

MV1816B
MV1816B1



CASE 48

MV1816A
MV1816A1

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	2.5	Adc
RF Power Input	P_{in}	10	Watts
Total Device Dissipation @ T_C = 25°C	P_D		
MV1816A, MV1816B		7.5	Watts
Derate above 25°C		43	mW/°C
MV1816A1, MV1816B1		11.5	Watts
Derate above 25°C		66	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	75	103	-	Vdc
Reverse Current		I_R				μAdc
(V_R = 60 Vdc)			-	-	1.0	
(V_R = 60 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance (C_J + C_C)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1816A		2.5	-	3.7	
	MV1816A1		2.8	-	3.4	
	MV1816B		2.4	-	3.6	
	MV1816B1		2.7	-	3.3	
Case Capacitance	MV1816A, MV1816A1	C_C	-	0.25	-	pF
	MV1816B, MV1816B1		-	0.15	-	
Series Inductance		L_S	-	0.85	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.57	-	Ohm
Minority Carrier Lifetime (I_F = 1.7 I_R, when I_F = 10 mA)	MV1816B1	τ	-	580	-	ns
Transition Time (I_F = 10 mA, Z_L = 50 ohms; measured between the 20% and 80% points)		t_t	-	1.25	-	ns
Thermal Resistance	MV1816A, MV1816B	θ_{JC}	-	-	23	°C/W
	MV1816A1, MV1816B1		-	8.5	15	

FUNCTIONAL TEST

Power Output	X 8 Test Circuit (Figure 1) P_{in} = 3.0 W, f_{in} = 300 MHz, f_{out} = 2.4 GHz	MV1816A, MV1816B	P_{out}	0.6	-	-	Watt
		MV1816A1, MV1816B1		0.75	-	-	
Efficiency		MV1816A, MV1816B	η	20	-	-	%
		MV1816A1, MV1816B1		25	-	-	

FIGURE 1 — OCTUPLER TEST CIRCUIT

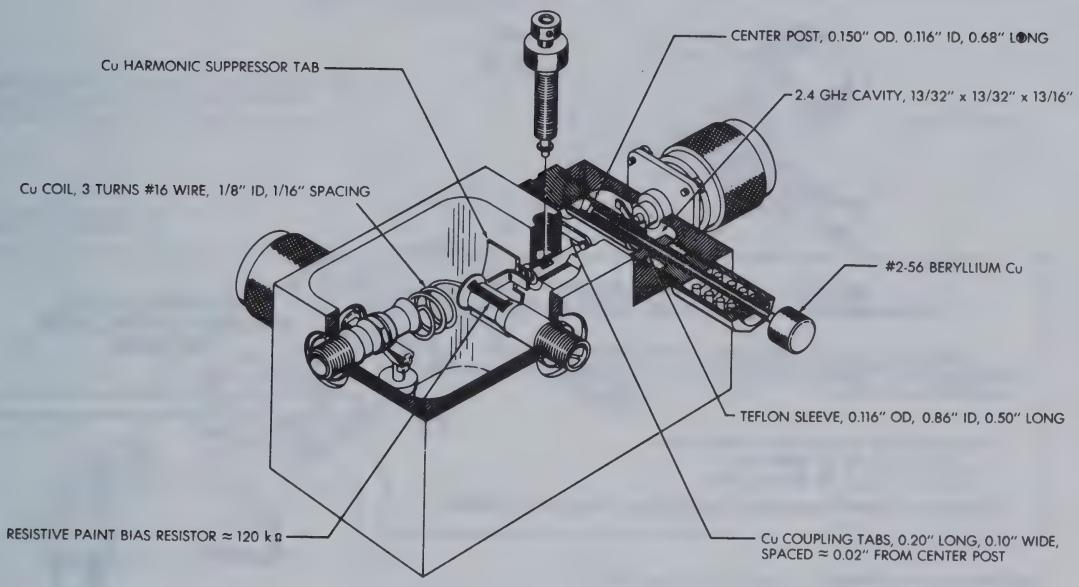


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

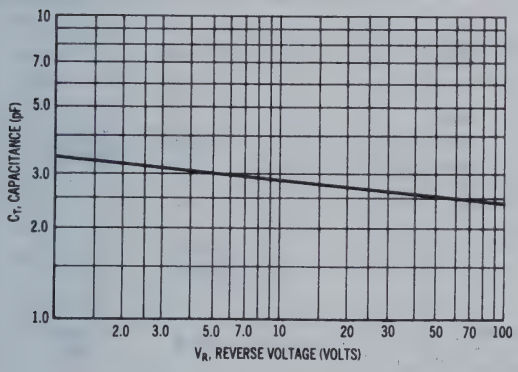


FIGURE 3 — OUTPUT POWER versus INPUT POWER

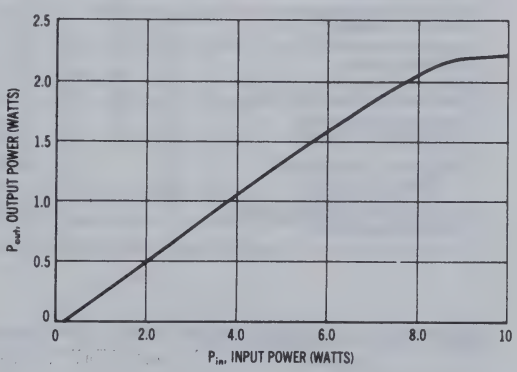
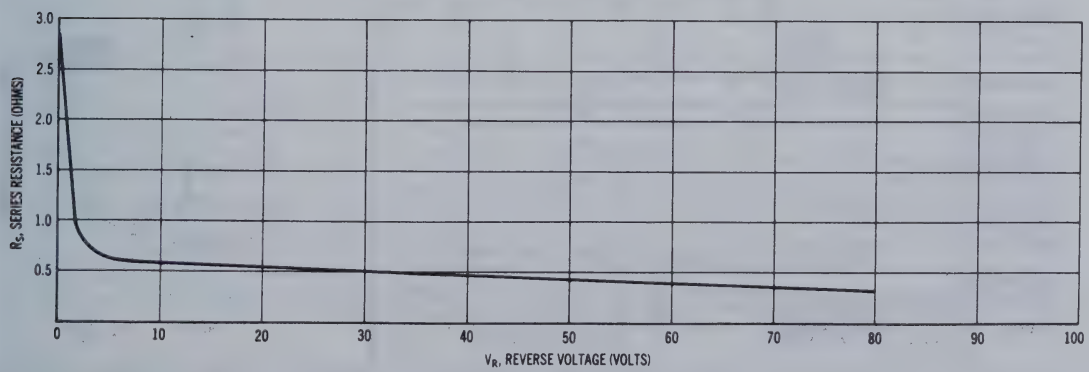


FIGURE 4 — SERIES RESISTANCE versus REVERSE VOLTAGE



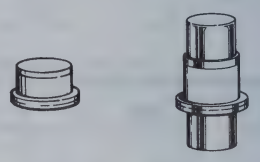
MV1817A, B (SILICON)
MV1817A1, B1

SILICON HIGH-FREQUENCY STEP-RECOVERY POWER VARACTORS

. . . designed for high efficiency in frequency multiplier applications. Permits ONE-STEP multiplication to frequencies as high as 8 GHz.

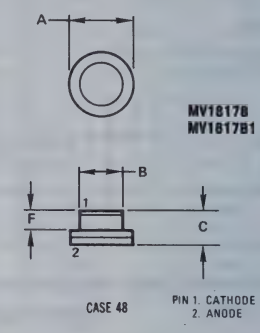
- Functionally Tested as X8 Multiplier
  Input: 1.0 W @ 800 MHz
  Output: 0.25 W @ 6.4 GHz
- Input RF Power Handling Capability as High as 2.0 Watts

STEP-RECOVERY POWER VARACTOR DIODES



MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc
Forward Current	I_F	0.80	Adc
RF Power Input	P_{in}	2.0	Watts
Total Device Dissipation @ T_C = 25°C	P_D		
MV1817A, MV1817B		5.0	Watts
Derate above 25°C		28	mW/°C
MV1817A1, MV1817B1		7.0	Watts
Derate above 25°C		40	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	35	60	-	Vdc
Reverse Current (V_R = 26 Vdc)		I_R	-	-	1.0	μAdc
(V_R = 26 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance (C_J + C_C)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1817A		0.9	-	1.3	
	MV1817A1		1.0	-	1.2	
	MV1817B		0.8	-	1.2	
	MV1817B1		0.9	-	1.1	
Case Capacitance	MV1817A, MV1817A1	C_C	-	0.25	-	pF
	MV1817B, MV1817B1		-	0.15	-	
Series Inductance		L_S	-	0.85	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.80	-	Ohm
Minority Carrier Lifetime (I_F = 1.7 I_R, when I_F = 10 mA)		τ	-	120	-	ns
Transition Time (I_F = 10 mA, Z_L = 50 ohms; measured between the 20% and 80% points)		t_t	-	0.4	-	ns
Thermal Resistance	MV1817A, MV1817B,	θ_{JC}	-	-	35	°C/W
	MV1817A1 MV1817B1		-	12.5	25	

FUNCTIONAL TESTS

Power Output	X 8 Test Circuit (Figure 1)	MV1817A, MV1817B	P_{out}	0.2	-	-	Watt
	P_{in} = 1.0 W,	MV1817A1, MV1817B1		0.25	-	-	
Efficiency	f_{in} = 800 MHz,	MV1817A, MV1817B	η	20	-	-	%
	f_{out} = 6.4 GHz	MV1817A1, MV1817B1		25	-	-	

FIGURE 1 — OCTUPLER TEST CIRCUIT

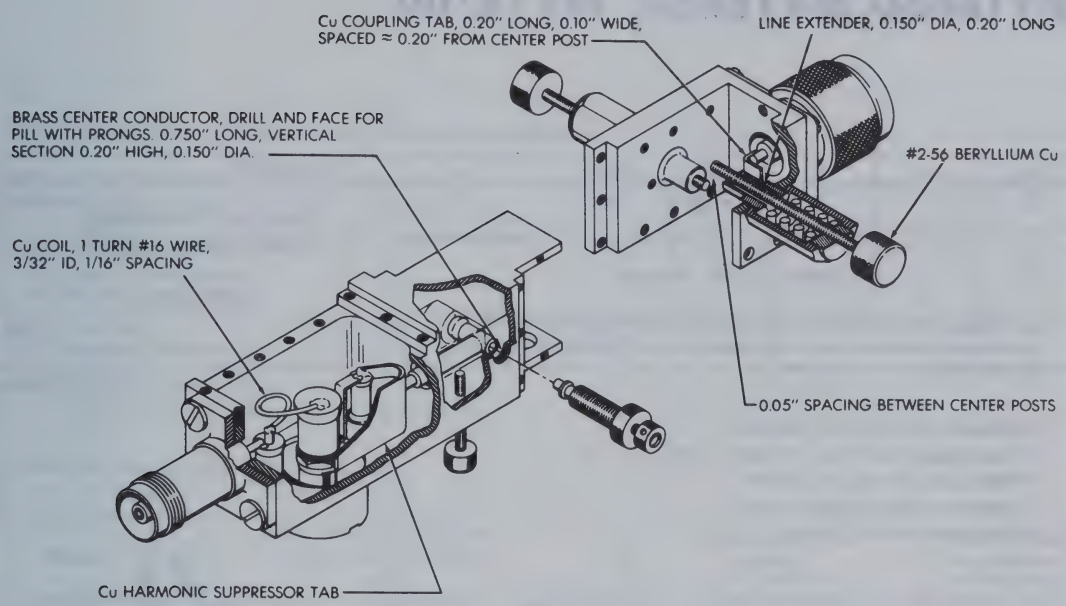


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

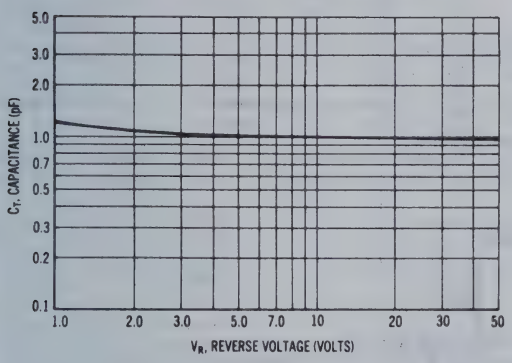


FIGURE 3 — OUTPUT POWER versus INPUT POWER

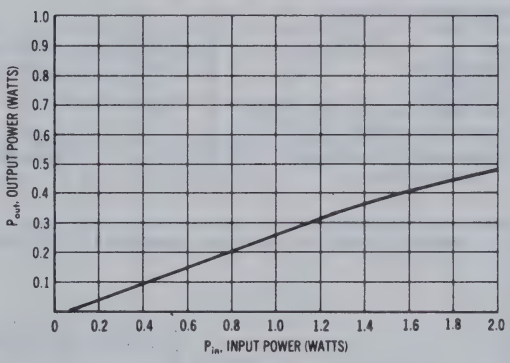
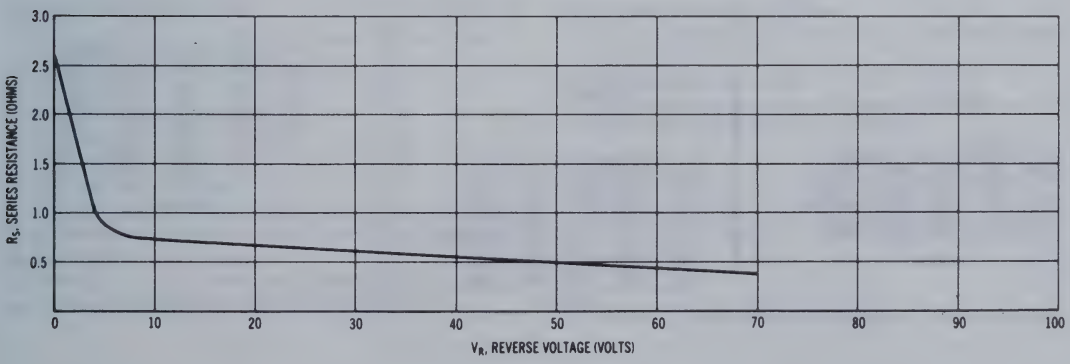


FIGURE 4 — SERIES RESISTANCE versus REVERSE VOLTAGE



MV1858D, MV1860D, MV1862D, (SILICON) MV1863D, MV1864D, MV1865D, MV1866D, MV1868D, MV1870D

VVC

SILICON EPICAP DIODES

. . . designed for electronic tuning and control applications in the UHF and lower microwave frequency ranges, where extremely high Q and broad tuning ratio are required.

- Excellent Q Factor @ f = 100 MHz
- Low Capacitance Values — as low as 1.0 pF
- Wide Tuning Range — to 60 Volts
- Complete Typical Design Curves
- Microwave Ceramic Package

VOLTAGE-VARIABLE CAPACITANCE DIODES

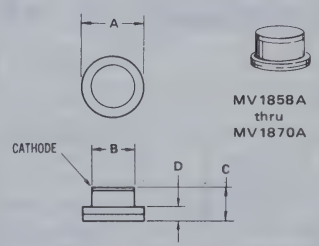
1 to 15 pF
60 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

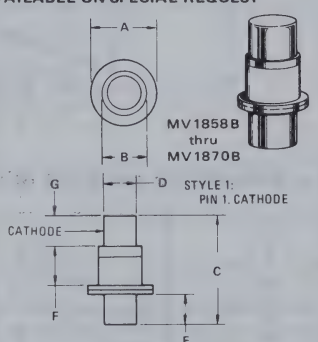
THE FOLLOWING PACKAGES ARE AVAILABLE ON SPECIAL REQUEST



MV1858A thru MV1870A

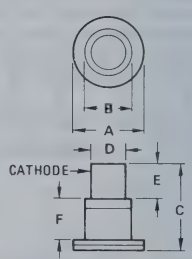
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.970	3.300	0.117	0.130
B	1.960	2.110	0.077	0.083
C	1.270	1.780	0.050	0.070
D	0.940	1.090	0.037	0.043

CASE 48



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.970	3.300	0.117	0.130
B	1.950	2.210	0.077	0.087
C	5.210	5.710	0.205	0.225
D	1.520	1.670	0.060	0.066
E	1.500	1.650	0.059	0.065
F	1.780	1.930	0.070	0.076
G	1.500	1.650	0.059	0.065

CASE 46



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.970	3.300	0.117	0.130
B	1.960	2.210	0.077	0.087
C	3.780	4.090	0.149	0.161
D	1.520	1.680	0.060	0.066
E	1.500	1.650	0.059	0.065
F	1.780	1.930	0.070	0.076

CASE 45

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	B_{VR}	60	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 55 Vdc)	I_R	–	–	0.02	μAdc
(V_R = 55 Vdc, T_A = 150°C)		–	–	20	
Series Inductance (f = self-resonant frequency)	L_S	–	0.8	–	nH
Case Capacitance (1) (f = 1.0 MHz)	C_C	–	0.15	–	pF

Device	C_T, Diode Capacitance (2) V_R = 4 Vdc, f = 1.0 MHz pF			C_R, Capacitance Ratio C_4/C_{60} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 100 MHz
	Min	Nom	Max	Min	Max	Min
MV1858D	0.70	1.0	1.30	2.1	2.7	350
MV1860D	1.76	2.2	2.64	2.5	3.1	350
MV1862D	2.97	3.3	3.63	2.6	3.3	300
MV1863D	4.23	4.7	5.17	2.6	3.3	300
MV1864D	6.10	6.8	7.50	2.7	3.4	300
MV1865D	7.38	8.2	9.02	2.7	3.4	300
MV1866D	9.00	10.0	11.00	2.8	3.5	250
MV1868D	10.80	12.0	13.20	2.8	3.5	200
MV1870D	13.50	15.0	16.50	2.8	3.5	200

(1) Case Capacitance = 0.25 pF typical for types MV1858A thru MV1870A (case 48).
(2) All C_T values 0.11 pF higher for types MV1858A thru MV1870A (case 48). C_R is reduced proportionately.

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is determined from the self resonant frequency and the junction capacity of the device.

$$L_S = \frac{1}{\omega^2_{res} C_J}$$

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

4. C_R, CAPACITANCE RATIO

C_R is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.

5. R_S, SERIES RESISTANCE

R_S is calculated from the insertion loss observed when the diode is resonated across a 50-ohm transmission line.

$$R_S = \frac{25}{-1\left(\frac{\text{Insertion Loss}}{20}\right)-1}$$
$$\log_{10}$$

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

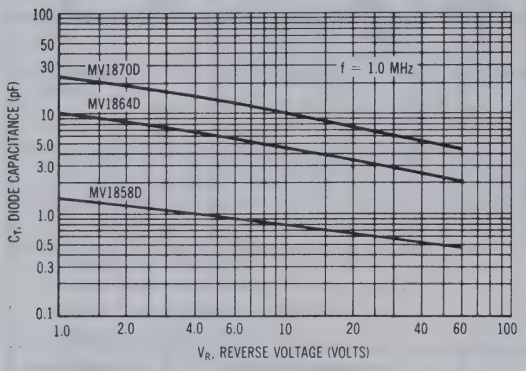


FIGURE 2 – NORMALIZED SERIES RESISTANCE versus REVERSE VOLTAGE

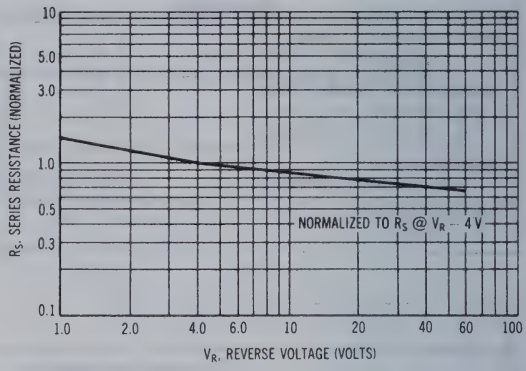


FIGURE 3 – CAPACITANCE VARIATION versus TEMPERATURE

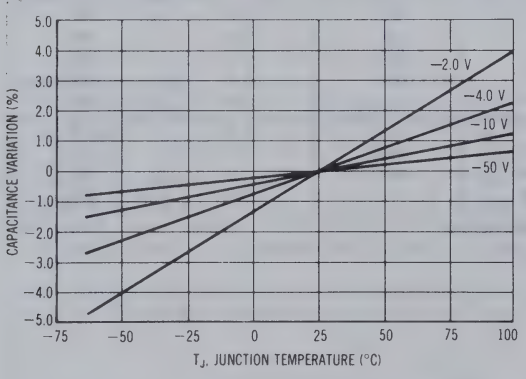


FIGURE 4 – NORMALIZED SERIES RESISTANCE versus TEMPERATURE

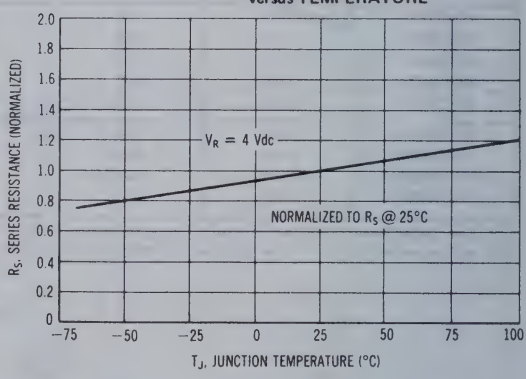


FIGURE 5 – REVERSE CURRENT

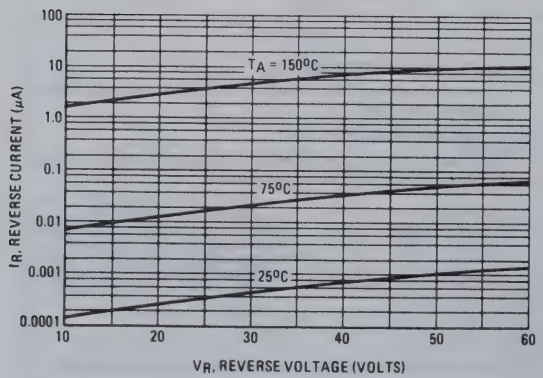
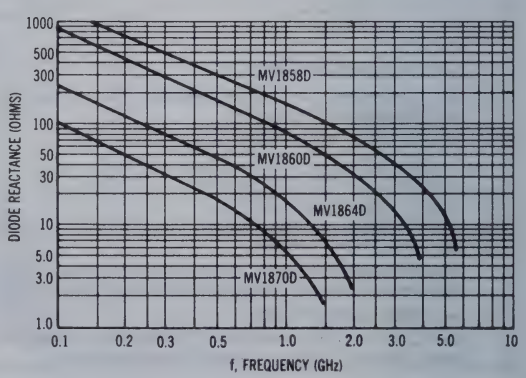


FIGURE 6 – DIODE REACTANCE versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. EPICAP NETWORK PRESENTATION

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_s, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:
- C_J — Voltage-Variable Junction Capacitance
- R_s — Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C — Case Capacitance
- L_s — Series Inductance
- R_J — Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

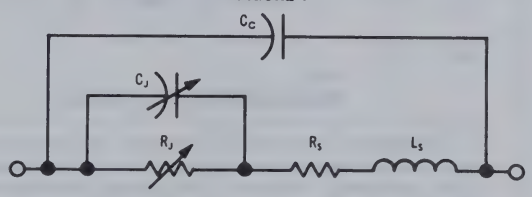
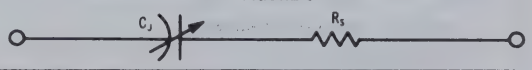


FIGURE 8



B. EPICAP CAPACITANCE vs REVERSE BIAS VOLTAGE

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Since the designer is primarily interested in the slope of C_T versus V_R, the C_C, C_o, ϕ, and γ characteristics have been encompassed by the simplified equation 3. Min/max limits on α can be guaranteed over a specified V_R range.

$$C_T = C_C + C_J \quad (1)$$

$$C_T = C_C + \frac{C_o}{(1 + \frac{V_R}{\phi})^\gamma} \quad (2)$$

$C_o = C_J$ at $V_R = 0$ $\qquad$ V_R = Reverse Bias

ϕ = Contact Potential, $\phi \approx 0.6$ Volt $\qquad$ $\gamma = C_J$ slope, $\gamma \approx 0.5$

$$C_T = \frac{K}{V_R^\alpha} \quad (3)$$

C. EPICAP CAPACITANCE vs FREQUENCY

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_s and R_J. The admittance expression for such a circuit is given in equation 4. Examination of equation 4 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_sC_J$; and as ω^2 is increased from $1/L_sC_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1 MHz. As ω approaches $\omega_o = 1/\sqrt{L_sC_J}$, small variations in L_s cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_c + \frac{j\omega C_J}{1 - \omega^2 L_s C_J} \quad (4)$$

D. EPICAP FIGURE OF MERIT (Q) AND CUTOFF FREQUENCY (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 5. For very low frequencies, equation 6 applies whereas at high frequencies, where R_J can be neglected, equation 5 may be rewritten into the familiar form of equation 7.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 8 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \quad (5)$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_s(1 + \omega^2 C_J^2 R_J^2)} \quad (6)$$

$$Q_{hf} = \frac{1}{\omega R_s C_{eq}} \quad (7)$$

$$f_{co} = Qf_{max} \approx \frac{1}{2\pi R_s C_{BVR}} \quad (8)$$

E. HARMONIC GENERATION USING EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 9 gives the level of maximum input power for the EPICAP and equation 10 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_s} \frac{f_{in}}{f_{co}} \quad (9)$$

$M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196$

$$Eff = 1 - N\frac{f_{out}}{f_{co}} \quad (10)$$

$N(x2) = 20.8;\ N(x3) = 34.8;\ N(x4) = 62.5$

M and N are Constants

MV1866, MV1868, MV1870, (SILICON)
MV1871, MV1872, MV1874,
MV1876, MV1877, MV1878

VVC

SILICON EPICAP DIODES

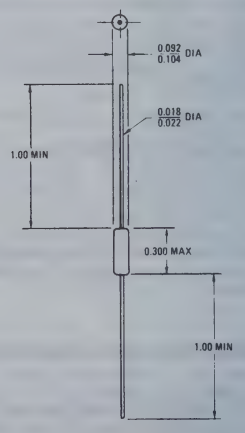
. . . a PREMIUM line of epitaxial, passivated, abrupt-junction tuning diodes designed for electronic tuning, FM AFC and harmonic generation applications into the microwave range providing solid-state reliability to replace mechanical tuning methods.

- Excellent Unit-to-Unit Uniformity
- Typical Design Curves
- Guaranteed Temperature Coefficient
- Guaranteed Q at Specified Reverse Voltages
- Guaranteed Capacitance Slope versus Reverse Voltage
- Guaranteed Min/Max Slope of Capacitance versus Reverse Voltage Curve (α)
- Complete Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

10–47 pF
60 VOLTS





To convert inches to millimeters multiply by 25.4
All JEDEC dimensions and notes apply

CASE 51
DO-7 – GLASS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Vdc
Forward Current	I_F	250	mAdc
RF Power Input (Note 1)	P_{in}	5.0	Watts
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.67	mW $mW/^oC$
Total Device Dissipation @ $T_L = 25^oC$ Derate above 25^oC	P_L	2.0 13.3	Watts $mW/^oC$
Operating Junction Temperature Range	T_J	+175	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

Note 1. The RF power input rating assumes that an adequate heat sink is provided.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Breakdown Voltage (I_R = 10 μAdc)	BV_R	60	75	–	Vdc
Reverse Current (V_R = 55 Vdc)	I_R	–	–	0.02	μAdc
(V_R = 55 Vdc, T_A = 150°C)		–	–	2.0	
Series Inductance (f = 250 MHz, Measured at Lead Stop ≈ 1/16")	L_S	–	5.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.17	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	200	300	ppm/°C
Cutoff Frequency (V_R = 60 Vdc, f = 50 MHz)	f_{CO}	–	45	–	GHz

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit f = 50 MHz		α, Diode Capacitance Reverse Voltage Slope V_R = 4.0 Vdc to V_R = 60 Vdc See B on Back Page			C_R, Capacitance Ratio C4.0/C60 f = 1.0 MHz		
				V_R = 4.0 Vdc	V_R = 60 Vdc						
	Min	Nom	Max	Min	Min	Min	Typ	Max	Min	Typ	Max
MV1866	9.0	10.0	11.0	500	700	0.42	0.44	0.48	3.0	3.1	3.5
MV1868	10.8	12.0	13.2	500	700	0.42	0.44	0.48	3.0	3.1	3.5
MV1870	13.5	15.0	16.5	400	700	0.42	0.45	0.48	3.0	3.2	3.5
MV1871	16.2	18.0	19.8	400	700	0.42	0.45	0.48	3.0	3.2	3.5
MV1872	19.8	22.0	24.2	400	700	0.45	0.46	0.48	3.2	3.3	3.5
MV1874	24.3	27.0	29.7	300	700	0.45	0.46	0.48	3.2	3.3	3.5
MV1876	29.7	33.0	36.3	300	700	0.45	0.47	0.48	3.2	3.4	3.6
MV1877	36.7	39.0	42.9	300	700	0.45	0.47	0.48	3.2	3.4	3.6
MV1878	42.3	47.0	51.7	300	700	0.45	0.47	0.48	3.2	3.4	3.6

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **C_R, Capacitance Ratio**
   C_R is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

   (Boonton Electronics Model 33AS8 or equivalent).

6. **TC_C, Diode Capacitance Temperature Coefficient**
   TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

   Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 – DIODE CAPACITANCE

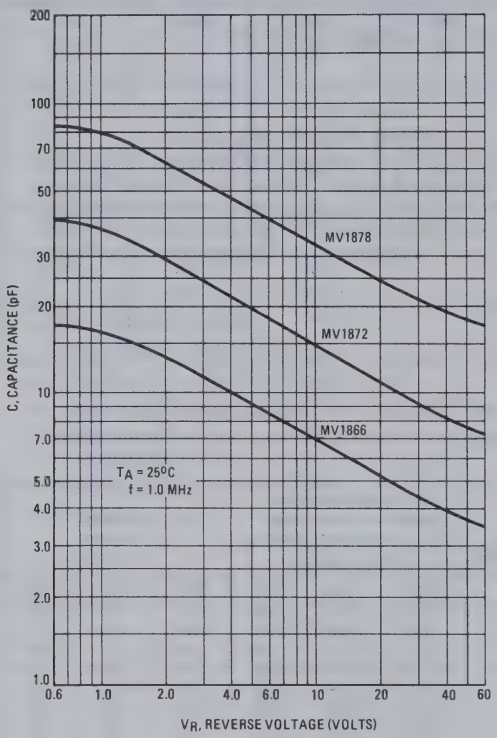


FIGURE 2 – FIGURE OF MERIT

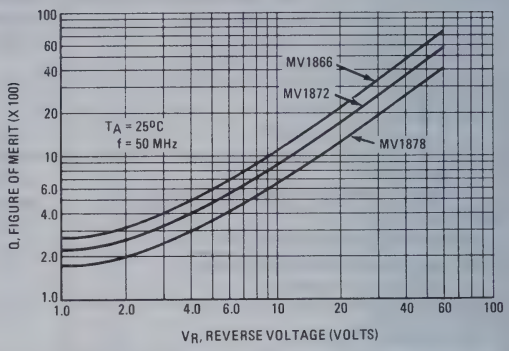


FIGURE 3 – FIGURE OF MERIT

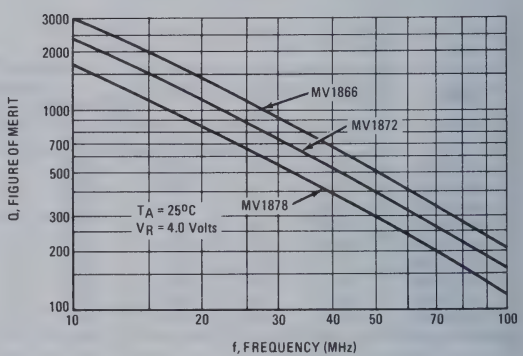


FIGURE 4 – DIODE CAPACITANCE

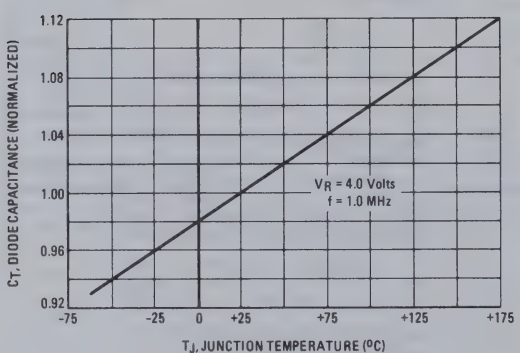
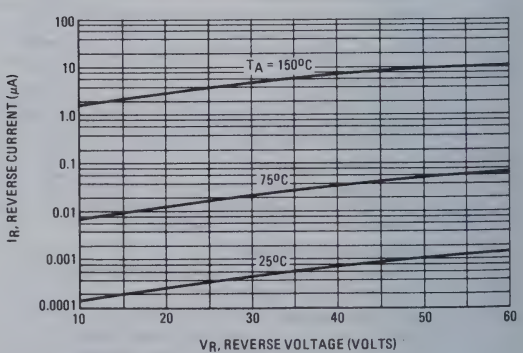


FIGURE 5 – REVERSE CURRENT



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:

- C_J – Voltage-Variable Junction Capacitance
- R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C – Case Capacitance
- L_S – Series Inductance
- R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

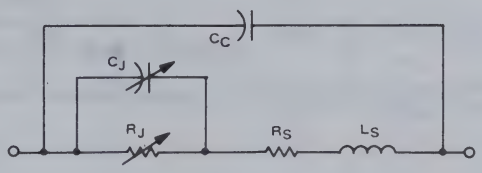


FIGURE 8



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Capacitance Ratio, CR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_C \approx 0.17$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{max} \quad \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \quad \frac{f_{in}}{f_{co}} \tag{10}$$

$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$\text{Eff} = 1 - N \quad \frac{f_{out}}{f_{co}} \tag{11}$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants

MV2101 (SILICON)
thru
MV2115

VVC

SILICON EPICAP DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance—10%
- Complete Typical Design Curves

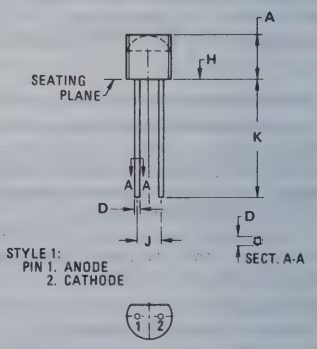
VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–100 pF
30 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.45	4.70	0.175	0.185
D	0.41	0.48	0.016	0.019
J	2.29	2.79	0.090	0.110
K	12.70	–	0.500	–

CASE 182-03

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		
Device	Min	Nom	Max	Min	Min	Typ	Max
MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MV2102	7.4	8.2	9.0	450	2.5	2.8	3.2
MV2103	9.0	10.0	11.0	400	2.5	2.9	3.2
MV2104	10.8	12.0	13.2	400	2.5	2.9	3.2
MV2105	13.5	15.0	16.5	400	2.5	2.9	3.2
MV2106	16.2	18.0	19.8	350	2.5	2.9	3.2
MV2107	19.8	22.0	24.2	350	2.5	2.9	3.2
MV2108	24.3	27.0	29.7	300	2.5	3.0	3.2
MV2109	29.7	33.0	36.3	200	2.5	3.0	3.2
MV2110	35.1	39.0	42.9	150	2.5	3.0	3.2
MV2111	42.3	47.0	51.7	150	2.5	3.0	3.2
MV2112	50.4	56.0	61.6	150	2.6	3.0	3.3
MV2113	61.2	68.0	74.8	150	2.6	3.0	3.3
MV2114	73.8	82.0	90.2	100	2.6	3.0	3.3
MV2115	90.0	100.0	110.0	100	2.6	3.0	3.3

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \cdot \frac{10^6}{C_R(25^\circ C)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.

TYPICAL DEVICE PERFORMANCE

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

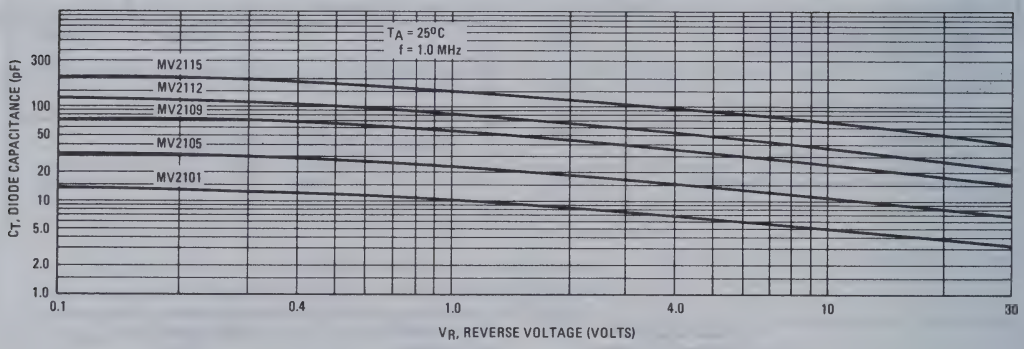


FIGURE 2 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

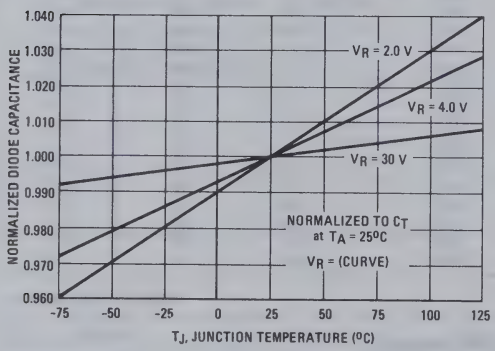


FIGURE 3 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

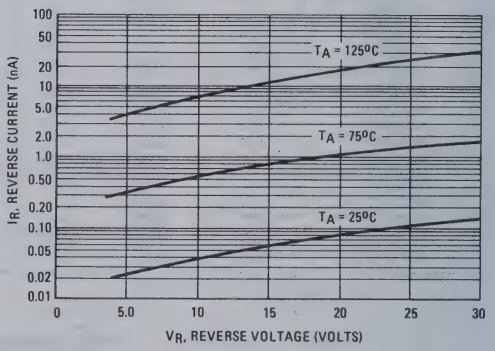


FIGURE 4 – FIGURE OF MERIT versus REVERSE VOLTAGE

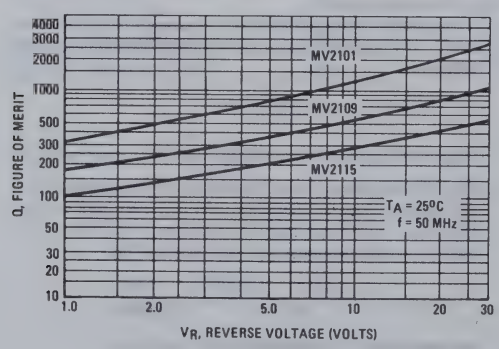
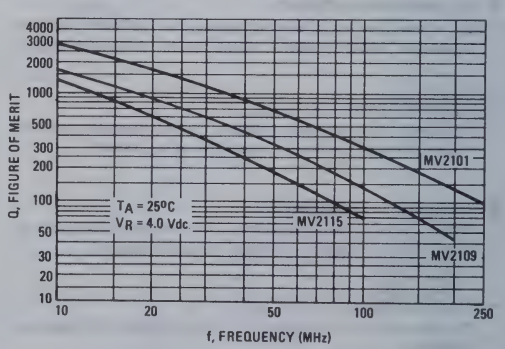


FIGURE 5 – FIGURE OF MERIT versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 6 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 7 represents the diode under these conditions.

Definitions:

- C_J – Voltage-Variable Junction Capacitance
- R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C – Case Capacitance
- L_S – Series Inductance
- R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 6

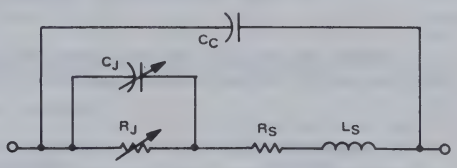


FIGURE 7



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

Conditions:

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.18$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 6, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2)} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{meas} \approx \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{10}$$

M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196

$$\text{Eff} = 1 - N\frac{f_{out}}{f_{co}} \tag{11}$$

N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5

M and N are Constants

MV2201, MV2203 (SILICON)
MV2205, MV2209

VVC

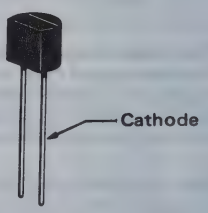
AFC SILICON EPICAP DIODES

. . . designed specifically for the high volume AFC applications of FM Radio and TV, utilizing the economical PLASTIC PACKAGE.

- Very High Q with Guaranteed Minimum Values
- Guaranteed Uniformity with Minimum and Maximum Tuning Ratio Limits, Assuring Fixed Design
- Nominal Capacitance Values – 6.8 pF Thru 33 pF – Providing Complete AFC Design Flexibility

VOLTAGE-VARIABLE CAPACITANCE DIODES

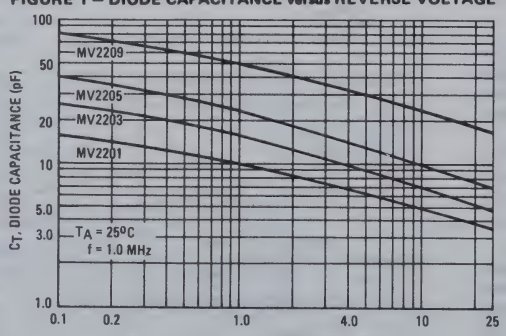
6.8–33 pF
25 VOLTS

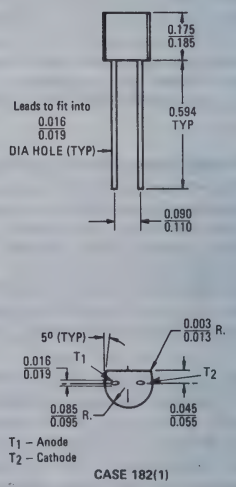


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	25	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE





CASE 182(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	25		–	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C)	I_R	–	–	0.5	μAdc
(V_R = 10 Vdc, T_A = 85°C)		–	–	5.0	
Forward Voltage Drop (I_F = 250 μAdc)	V_F	–	0.65	–	Vdc
Series Inductance (f = 250 MHz, lead length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, lead length ≈ 1/16")	C_C	–	0.18	–	pF

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF		Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_1/C_{10} f = 1.0 MHz	
Device	Min	Max	Min	Min	Max
MV2201	5.5	8.0	300	1.9	2.3
MV2203	8.5	11.5	200	2.0	2.4
MV2205	13	17	200	2.1	2.5
MV2209	29	37	150	2.1	2.5

FIGURE 2 – FIGURE OF MERIT versus REVERSE VOLTAGE

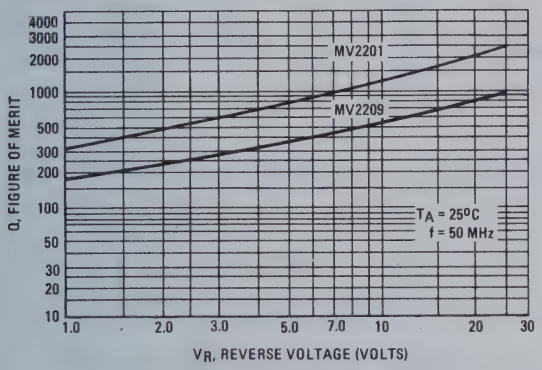


FIGURE 3 – FIGURE OF MERIT versus FREQUENCY

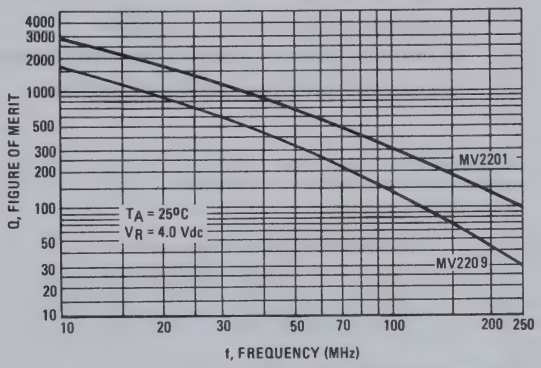
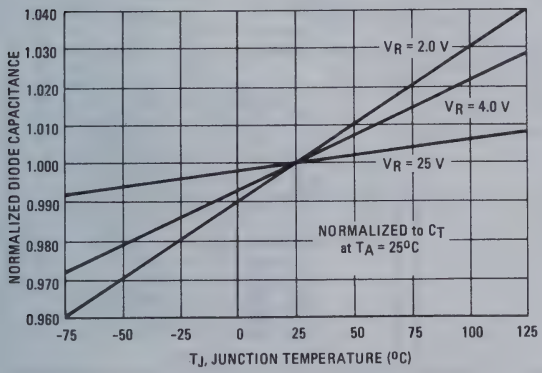


FIGURE 4 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



NOTES ON TESTING AND SPECIFICATIONS

L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

MV2301 (SILICON)
thru
MV2308

VVC

SILICON EPICAP DIODES

. . . epitaxial passivated tuning diodes designed for general tuning, trimming and AFC applications at low radio frequencies.

- Standard Capacitance Values to 330 pF
- Maximum Working Voltage of 20 V
- Excellent Q Factor at High Frequencies
- Guaranteed Minimum Q and Tuning Ratio
- Solid-State Reliability to Replace Mechanical Tuning Methods
- Low-Cost-Plastic Package for Economical Design

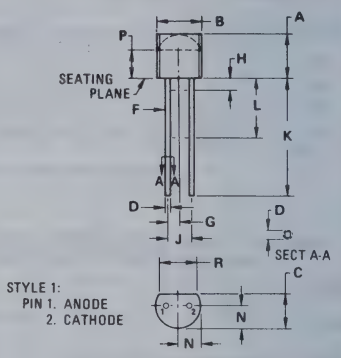
VOLTAGE-VARIABLE CAPACITANCE DIODES

120–330 pF
20 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	400	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	500 5.0	mW mW/^oC
Junction Temperature	T_J	+125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

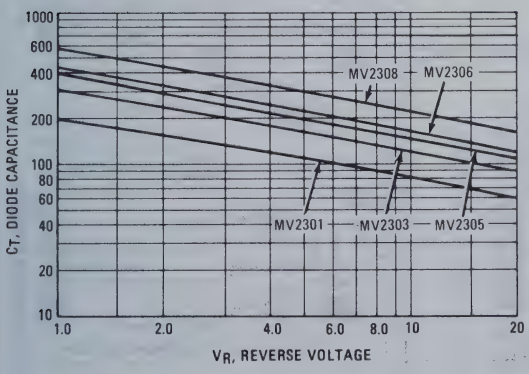
CASE 182-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	20	–	–	Vdc
Reverse Current (V_R = 15 Vdc)	I_R	–	–	0.1	μAdc
Series Inductance	L_S	–	6.0	–	nH
Case Capacitance	C_C	–	0.18	–	pF

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz			Q, Figure of Merit V_R = 4.0 Vdc, f = 20 MHz	Capacitance Ratio C_2/C_{20}
	Min	Nom	Max	Minimum	Minimum
MV2301	108	120	135	250	2.3
MV2302	132	150	165	250	2.3
MV2303	162	180	198	200	2.3
MV2304	180	200	220	200	2.3
MV2305	198	220	242	150	2.3
MV2306	225	250	275	150	2.3
MV2307	243	270	300	100	2.3
MV2308	297	330	363	100	2.3

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE



PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE:**
Determined from the self resonant frequency (ω_o) and the junction capacity of the device, C_J.

$$L_S = \frac{1}{\omega_o^2 C_J}$$

2. **C_T, DIODE CAPACITANCE:**
Measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent). ($C_T = C_C + C_J$).

3. **CAPACITANCE RATIO:**
The ratio of C_T measured at 2.0 Vdc divided by C_T measured at 20 Vdc.

4. **Q, FIGURE OF MERIT:**
Calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS9 with range extender or equivalent).

MV3102 (SILICON)
MV3103

VVC

SILICON EPICAP DIODES

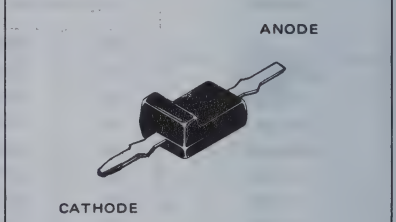
. . . designed in the new low-inductance Mini-L package for high volume requirements in VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Low Inductance Mini-L Package
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance along the entire specified tuning range.

VOLTAGE VARIABLE CAPACITANCE DIODES

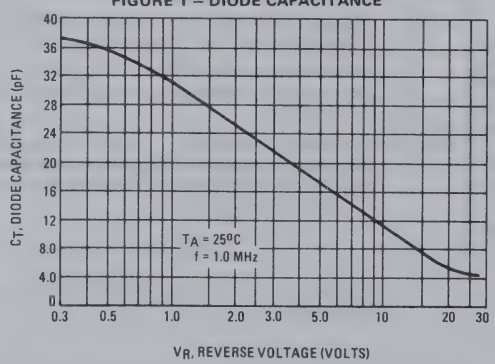
22 pF (Nominal)
30 VOLTS

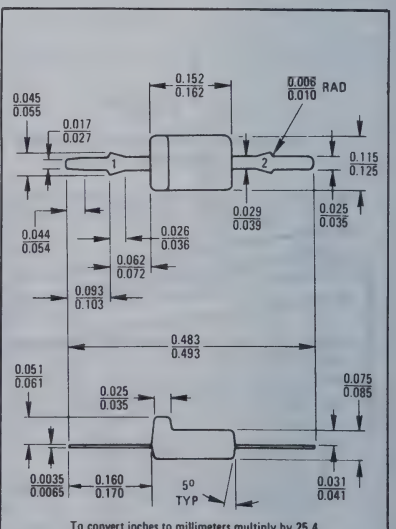


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – DIODE CAPACITANCE





To convert inches to millimeters multiply by 25.4

CASE 226

Pin 1. Cathode
2. Anode

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz		Package Stripe
Device	Min	Nom	Max	Min	Min	Typ	Color
MV3102	20	22	25	300	4.5	4.8	Green
MV3103	19	–	26	200	4.0	–	White

FIGURE 2 – FIGURE OF MERIT

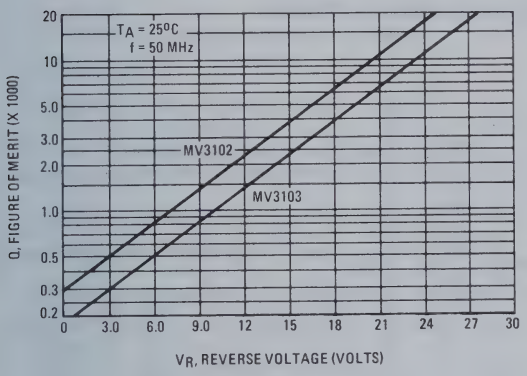


FIGURE 3 – LEAKAGE CURRENT

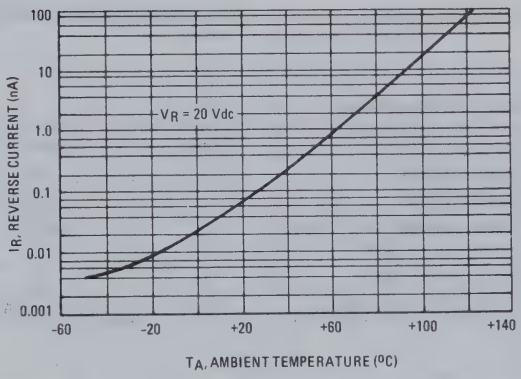
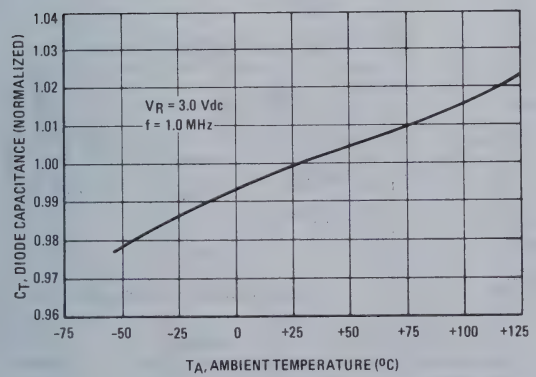


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV3140 (SILICON)
MV3141
MV3142

VVC

SILICON EPICAP DIODES

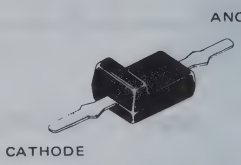
. . . designed in the new low-inductance mini-L package for high volume requirements of UHF and VHF TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Guaranteed Minimum Q Values at VHF and UHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±1.5% or 0.1 pF (whichever is greater) at all points along the specified tuning range.

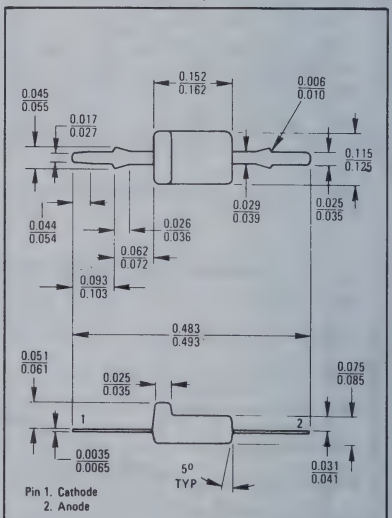
VOLTAGE VARIABLE CAPACITANCE DIODES

30 VOLTS



MAXIMUM RATINGS

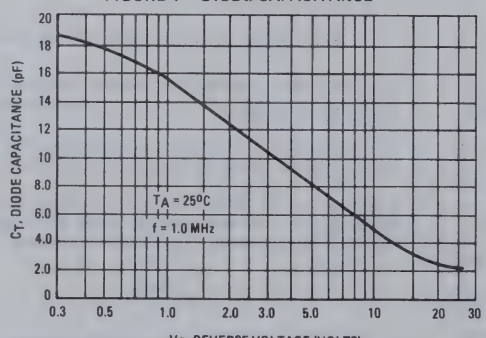
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



To convert inches to millimeters multiply by 25.4

CASE 226

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc V_R = 25 V pF		Q, Figure of Merit V_R = 3.0 Vdc f = 100 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz	Package Stripe
Device	Typ	Max	Min	Min	Color
MV3140	10.5	2.3	150	4.5	Blue
MV3141	10.5	3.2	150	4.0	White
MV3142	10.5	3.2	50	3.5	Orange

TYPICAL MV3140 ELECTRICAL CHARACTERISTICS

FIGURE 2 – FIGURE OF MERIT

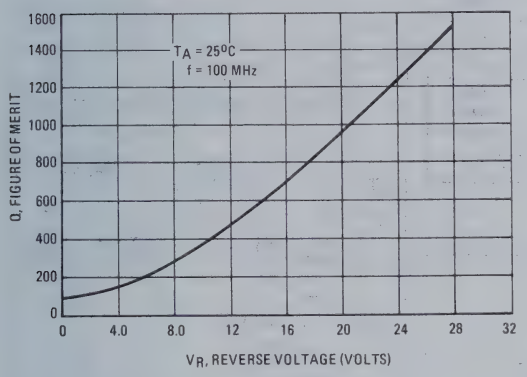


FIGURE 3 – LEAKAGE CURRENT

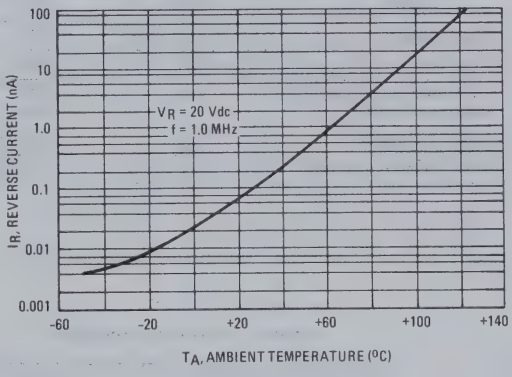
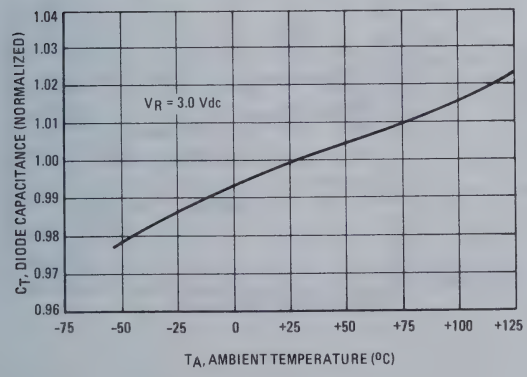


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV3501 (SILICON)
thru
MV3507

VVC

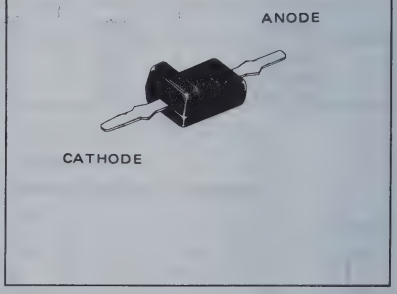
SILICON EPICAP DIODES

. . . designed in the new low-inductance Mini-L package for high-volume, low-cost frequency control and tuning applications; providing solid state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values @ 100 MHz
- Capacitance Values — 6.8 to 22 pF
- Ideal for RF and Microwave Applications
- Controlled and Uniform Capacitance Change

VOLTAGE-VARIABLE CAPACITANCE DIODES

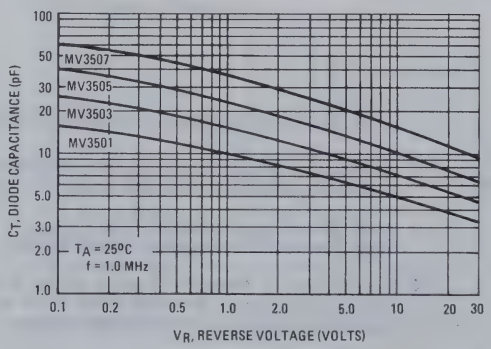
6.8–22 pF
30 VOLTS

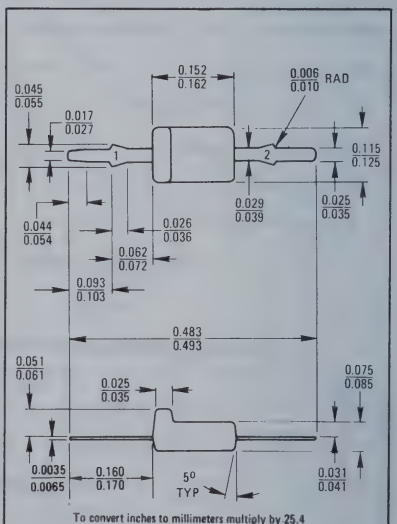


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 — DIODE CAPACITANCE





To convert inches to millimeters multiply by 25.4

CASE 226

Pin 1. Cathode
2. Anode

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current	I_R				μAdc
(V_R = 25 Vdc)		–	–	0.1	
(V_R = 25 Vdc, T_A = 85°C)		–	–	5.0	
Series Inductance (f = 250 MHz, measured at lead stop ≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 100 MHz	C_R, Capacitance Ratio C2/C30 f = 1.0 MHz	Package Stripe
Device	Min	Nom	Max	Min	Min	Color
MV3501	6.1	6.8	7.5	225	2.7	Brown
MV3502	7.4	8.2	9.0	225	2.8	Red
MV3503	9.0	10	11	200	2.8	Orange
MV3504	10.8	12	13.2	200	2.8	Yellow
MV3505	13.5	15	16.5	200	2.9	Green
MV3506	16.2	18	19.8	175	2.9	Blue
MV3507	19.8	22	24.2	175	2.9	Violet

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – FIGURE OF MERIT

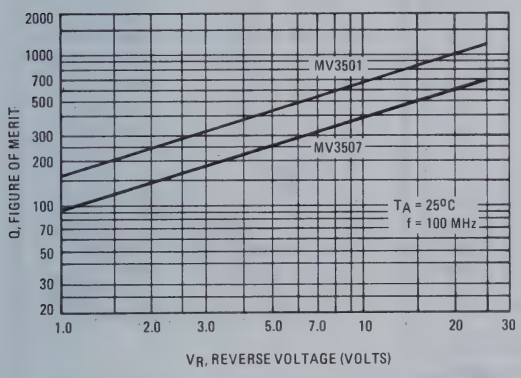


FIGURE 3 – FIGURE OF MERIT

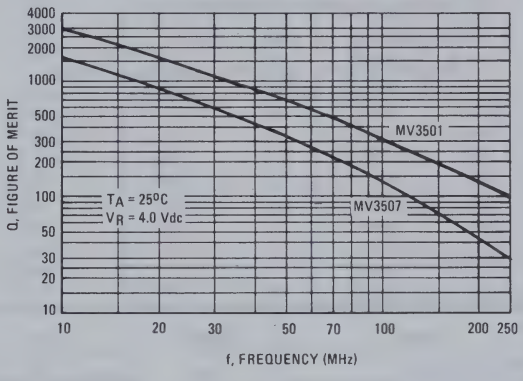
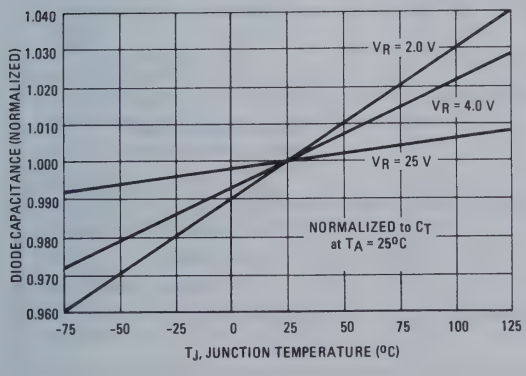


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

MVI-2097 thru MVI-2109 (SILICON)

VVC

SILICON EPICAP MICRO-I DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Electrically Similar to MV2101 Series
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance – 10%
- Complete Typical Design Curves
- Supplied in Space Saving Micro-Miniature Package

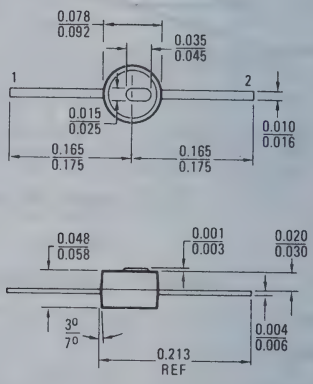
VOLTAGE-VARIABLE CAPACITANCE DIODES

1.0 – 33 pF
30 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	20	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

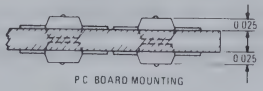


Optional Package with Raised Circular Tab Available; Specify Case 166-01.

STYLE 1:
PIN 1. ANODE
2. CATHODE

CASE 166-02

TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



P.C. BOARD MOUNTING

Maximum Solder Temperature 250°C for 10s

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	—	—	20	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	—	0.15	—	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	—	280	400	ppm/°C

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc f = 100 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Color Code	
	Min	Nom	Max	Min	Min	Max	Top	Bottom
MVI-2097	0.8	1.0	1.2	325	2.0	2.4	None	None
MVI-2098	1.8	2.2	2.7	325	2.0	2.8	None	Brown
MVI-2099	2.6	3.3	4.0	300	2.2	2.9	None	Red
MVI-2100	3.7	4.7	5.7	300	2.4	2.9	None	Orange
MVI-2101	6.1	6.8	7.5	275	2.5	3.3	None	Yellow
MVI-2102	7.3	8.2	9.0	275	2.6	3.3	None	Green
MVI-2103	9.0	10	11	275	2.6	3.3	None	Blue
MVI-2104	10.8	12	13.2	275	2.6	3.3	None	Violet
MVI-2105	13.5	15	16.5	275	2.6	3.3	None	Gray
MVI-2106	16.2	18	19.8	250	2.7	3.3	None	White
MVI-2107	19.8	22	24.2	200	2.7	3.3	Brown	None
MVI-2108	24.3	27	29.7	200	2.7	3.3	Brown	Brown
MVI-2109	29.7	33	36.3	200	2.7	3.3	Brown	Red

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \cdot \frac{10^6}{C_R(25^\circ C)}$$

Accuracy limited by measurement of C_T to ±0.1 pF.
C_R = Capacitance at V_R = 4.0 Vdc

TYPICAL CHARACTERISTICS

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

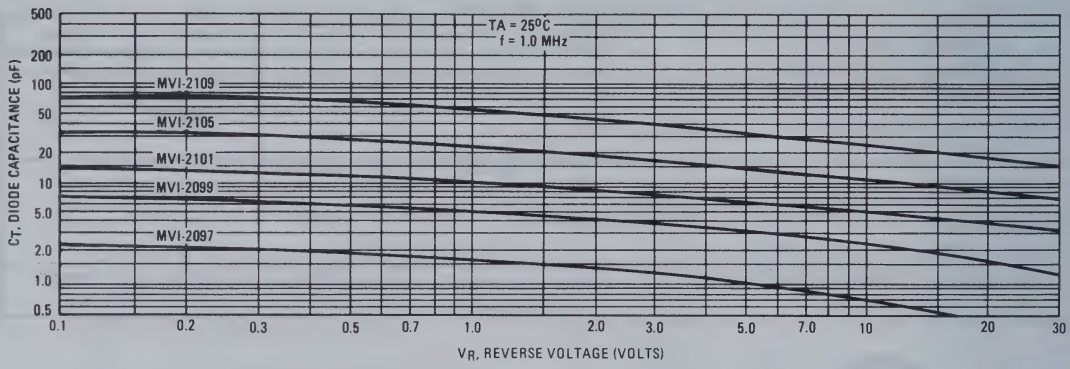


FIGURE 2 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

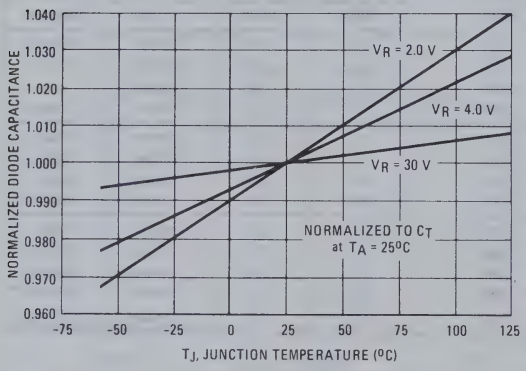


FIGURE 3 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

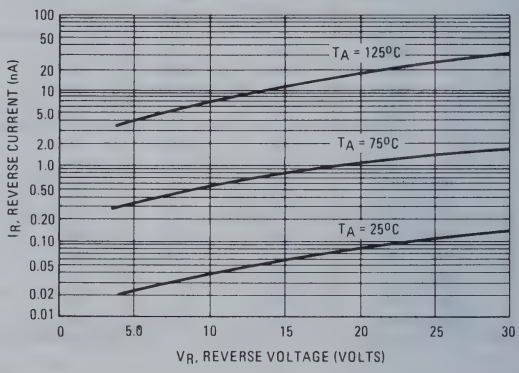


FIGURE 4 – FIGURE OF MERIT versus REVERSE VOLTAGE

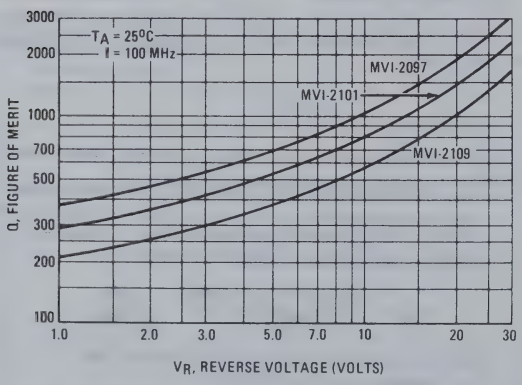
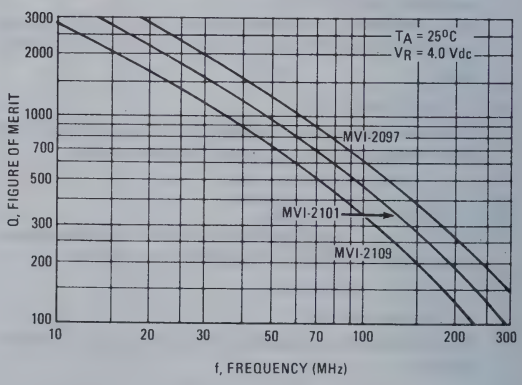


FIGURE 5 – FIGURE OF MERIT versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 6 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 7 represents the diode under these conditions.

Definitions:

- C_J – Voltage-Variable Junction Capacitance
- R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C – Case Capacitance
- L_S – Series Inductance
- R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 6

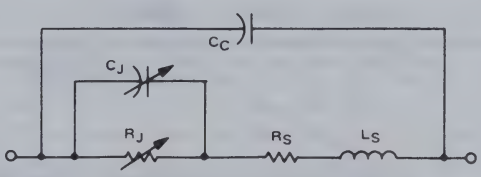


FIGURE 7



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

Conditions:

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_C \approx 0.18$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 6, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{meas} \approx \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{10}$$

$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$\text{Eff} = 1 - N\frac{f_{out}}{f_{co}} \tag{11}$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants

MVS460



MONOLITHIC TEMPERATURE COMPENSATED VOLTAGE REFERENCE DIODE

Highly reliable temperature compensated monolithic integrated circuit voltage stabilizer designed for use in television and FM radios that use variable capacitance diode tuners.

- Low Dynamic Operating Impedance
- Low Operating Voltage Change over Temperature Range

TUNING DIODE REGULATOR



MAXIMUM RATINGS

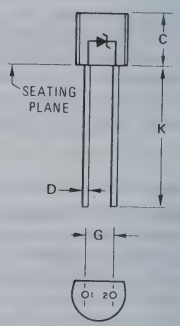
Rating	Symbol	Value	Unit
Operating Current for 33 V_Z	I_Z	18	mA
Power Dissipation @ T_A = 25°C	P_D	625	mW
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.083	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage (I_{ZT} = 5.0 mA)	V_Z	31	33	35	Volts
Operating Voltage Change (I_{ZT} = 5.0 mA, 0 to 70°C)	$\frac{\Delta V_Z}{\Delta T}$	-3.1	-2.3	+1.55	mV/°C
Operating Dynamic Impedance (I_Z = 5.0 mA)	Z_z	–	9.0	25	Ohms



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
C	0.175	0.185	4.45	4.70
D	0.016	0.019	0.406	0.483
G	0.090	0.110	2.29	2.79
K	0.594		15.09	

CASE 182-01

FIGURE 1 – POWER DERATING

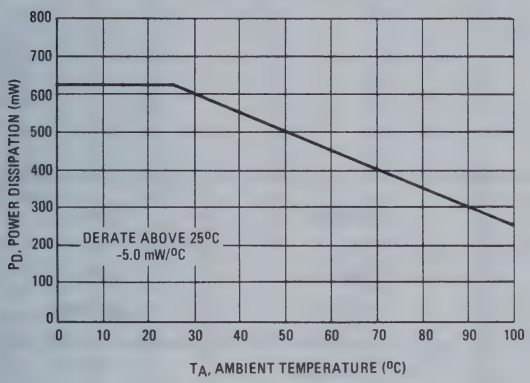


FIGURE 2 – CURRENT DERATING

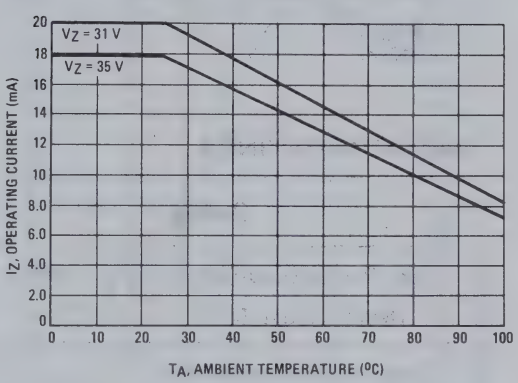


FIGURE 3 – OPERATING VOLTAGE CHANGE

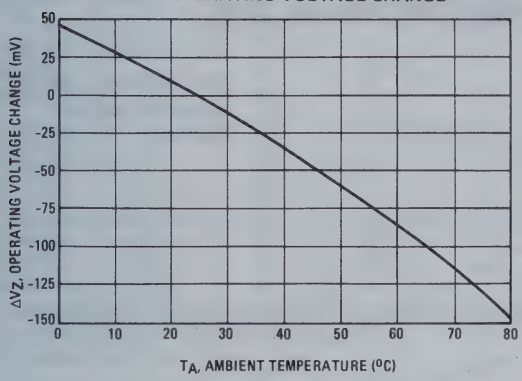


FIGURE 4 – OPERATING VOLTAGE CHANGE TEST CIRCUIT

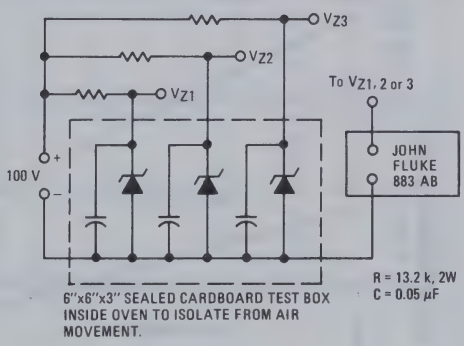


FIGURE 5 – OPERATING IMPEDANCE TEST CIRCUIT

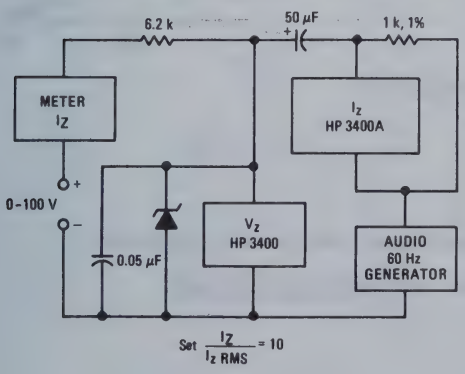
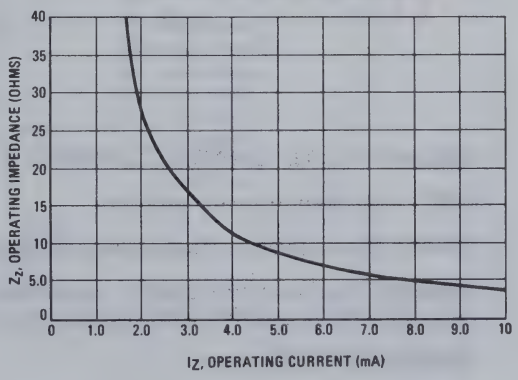


FIGURE 6 – OPERATING IMPEDANCE



MZ500-1 thru MZ500-40 (SILICON)



CASE 51
(DO-7)

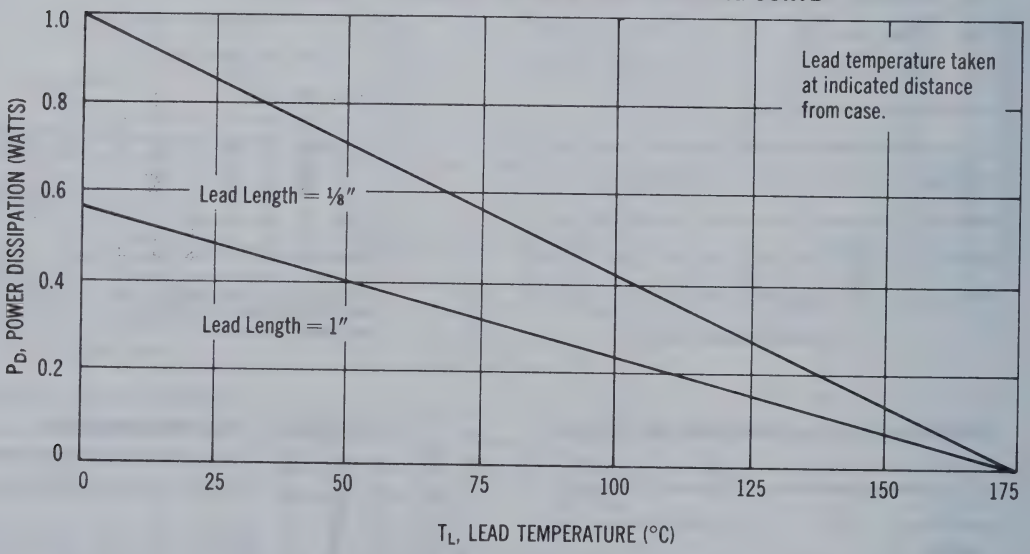
Miniature plastic encapsulated zener diodes for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C	400	mW
Derate above 50°C	3.2	mW/°C
Junction Temperature*	-65 to +175	°C

*Maximum lead temperature for 10 seconds at 1/16'' from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).

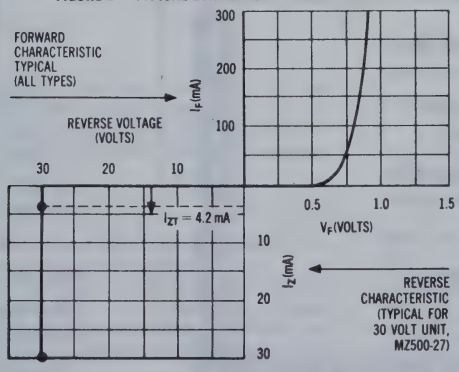
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Type No.	Zener Voltage V_Z @ I_{ZT} Volts*			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current I_R @ V_R		Typical Temperature Coefficient %/°C
	Min	Nom	Max				μA Max	Volts	
MZ500-1	2.16	2.4	2.64	20	35	150	—	—	-.085
MZ500-2	2.43	2.7	2.94	20	30	135	—	—	-.080
MZ500-3	2.7	3.0	3.3	20	30	120	—	—	-.075
MZ500-4	2.97	3.3	3.63	20	30	110	20	1	-.070
MZ500-5	3.24	3.6	3.96	20	25	100	20	1	-.065
MZ500-6	3.51	3.9	4.29	20	25	95	20	1	-.060
MZ500-7	3.87	4.3	4.73	20	25	85	5	1	-.050
MZ500-8	4.23	4.7	5.17	20	20	80	5	1	-.043
MZ500-9	4.59	5.1	5.61	20	20	70	5	1	±.030
MZ500-10	5.04	5.6	6.16	20	15	65	5	1	±.028
MZ500-11	5.58	6.2	6.82	20	10	60	5	1	+.045
MZ500-12	6.12	6.8	7.48	20	5	55	5	1	.050
MZ500-13	6.75	7.5	8.25	20	10	50	5	1	.058
MZ500-14	7.38	8.2	9.02	20	10	45	5	1	.062
MZ500-15	8.19	9.1	10.02	20	10	40	5	1	.068
MZ500-16	9.0	10	11.0	20	20	36	5	1	.075
MZ500-17	9.9	11	12.1	20	20	35	5	1	.076
MZ500-18	10.8	12	13.2	20	30	32	5	1	.077
MZ500-19	11.7	13	14.3	9.5	15	30	10	9.4	.079
MZ500-20	13.5	15	16.5	8.5	20	26	10	10.8	.082
MZ500-21	14.4	16	17.6	7.8	20	25	10	11.5	.083
MZ500-22	16.2	18	19.8	7.0	25	21	10	13.0	.085
MZ500-23	18.0	20	22.0	6.2	30	19	10	14.4	.086
MZ500-24	19.8	22	24.2	5.6	30	17	10	15.8	.087
MZ500-25	21.6	24	26.4	5.2	35	16	10	17.3	.088
MZ500-26	24.3	27	29.7	4.6	45	14	10	19.4	.090
MZ500-27	27.0	30	33.0	4.2	50	13	10	21.6	.091
MZ500-28	29.7	33	36.3	3.8	60	12	10	23.8	.092
MZ500-29	32.4	36	39.6	3.4	70	11	10	25.9	.093
MZ500-30	35.1	39	42.9	3.2	80	9.1	10	28.1	.094
MZ500-31	38.7	43	47.3	3.0	95	8.8	10	31.0	.095
MZ500-32	42.3	47	51.7	2.7	110	7.9	10	33.8	.095
MZ500-33	45.9	51	56.1	2.5	130	7.4	10	36.7	.096
MZ500-34	50.4	56	61.6	2.2	150	6.9	10	40.3	.096
MZ500-35	55.8	62	68.2	2.0	190	6.0	10	44.6	.097
MZ500-36	61.2	68	74.8	1.8	240	5.5	10	49.0	.097
MZ500-37	67.5	75	82.5	1.7	280	5.1	10	54.0	.098
MZ500-38	73.8	82	90.2	1.5	340	4.6	10	59.0	.098
MZ500-39	81.9	91	100.1	1.4	400	4.2	10	65.5	.099
MZ500-40	90.0	100	110.0	1.3	500	3.7	10	72.0	.100

*1. Nominal voltages other than those stated above, matched sets of tight voltage tolerance devices, tighter voltage tolerances and double anode clippers, are available from the .4M3.3ZS5 series on special request.

2. Voltages to 200 volts are available.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ600 SERIES (SILICON)
6.2 Volts
MZ800 SERIES
8.4 Volts

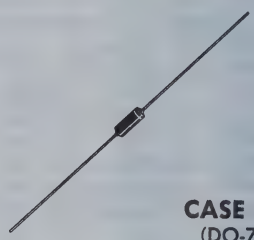
PRECISION REFERENCE DIODES

. . . designed, manufactured and tested for applications requiring a precision voltage reference with ultra-high stability of voltage with time and temperature change.

Special test laboratory uses precision measurement equipment, four-terminal (separate contacts for current and voltage) measurement techniques and voltage standards to provide calibration directly traceable to the National Bureau of Standards.

PRECISION REFERENCE DIODES

with CERTIFIED ZENER VOLTAGE-TIME STABILITY

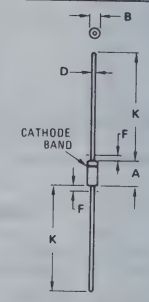


CASE 51
(DO-7)

Certified TEST DATA

Every Precision Reference Diode is individually serialized and its test data recorded on a Certificate of Precision that accompanies the device when shipped. This data shows:

- Device voltages at each test temperature (+25, +75 and +100°C)
- Voltage stability within the measuring temperature range
- Actual device voltage at 168 hour intervals during verification test
- Voltage stability throughout the entire 1000 hour test period
- Certification of Precision
- All diodes are marked with the device type number and polarity band



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F		1.27		0.050
K	25.40		1.000	

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA

MECHANICAL CHARACTERISTICS:

Case:
Glass, Hermetically Sealed

Leads: Dumet

Lead Finish:
Nickel 50-100 μin. then gold plated 50-200 μin.

Weight:
0.2 grams (approx)

OPERATING TEMPERATURE RANGE:* 25 to 100°C.

MZ600 SERIES (Voltage 6.2V ± 5%, I_{ZT} = 7.5 mAdc †, $\triangle V_z$ = 2.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ605	30 Maximum	< 5
MZ610	60 Maximum	<10
MZ620	120 Maximum	<20
MZ640	240 Maximum	<40

DYNAMIC IMPEDANCE: 10 ohms at I_{ZT} = 7.5 mAdc, I_{ac} = 0.75 mA.

MZ800 SERIES (Voltage 8.4V ± 5%, I_{ZT} = 10 mAdc†, $\triangle V_z$ = 3.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ805	45 Maximum	< 5
MZ810	90 Maximum	<10
MZ820	180 Maximum	<20
MZ840	360 Maximum	<40

DYNAMIC IMPEDANCE: 15 ohms at I_{ZT} = 10 mAdc, I_{ac} = 1.0 mA.

NOTES

†TEST CURRENT
For certification testing of time stability, Motorola maintains I_{ZT} constant and repeatable to ±0.05 μA tolerance. For voltage tolerance, impedance and voltage temperature stability I_{ZT} needs to be held to 0.01 mA tolerance only.

*Maximum limits for use as a precision reference device. Limits are well below the maximum thermal limits.

**VOLTAGE-TEMPERATURE STABILITY: Maximum allowable voltage change between voltages recorded at 25, 75 and 100° C ambient.

VOLTAGE-TIME STABILITY (ΔV_Z/1000 Hours).

The device voltage is read and recorded initially and at 168 hour intervals through 1000 hours. The maximum change of voltage between readings, taken at any of the seven points, must be less than the maximum voltage change per 1000 hours specified as Voltage-Time Stability.

TURN-ON CHARACTERISTICS

Precision Reference Diodes have been tested to determine the behavior of the device under interrupted power operation.

To insure specified performance, adequate time must be allowed for the device and its environment to reach thermal equilibrium. "Warm-up" time may range from 10 to 30 minutes. Thermal equilibrium is reached when the chamber is cycling at the required temperature with the device energized.

After this "warm-up" period, the device voltage will be between the minimum and the maximum voltage of those recorded at the seven points of the Voltage-Time Stability certification.

MOUNTING

Excellent results have been obtained by using a mechanical mounting. If necessary, the device may be soldered into a circuit using a heat sink between the heat source and the body of the diode. A low thermal EMF solder is recommended.

SPECIAL NOTE

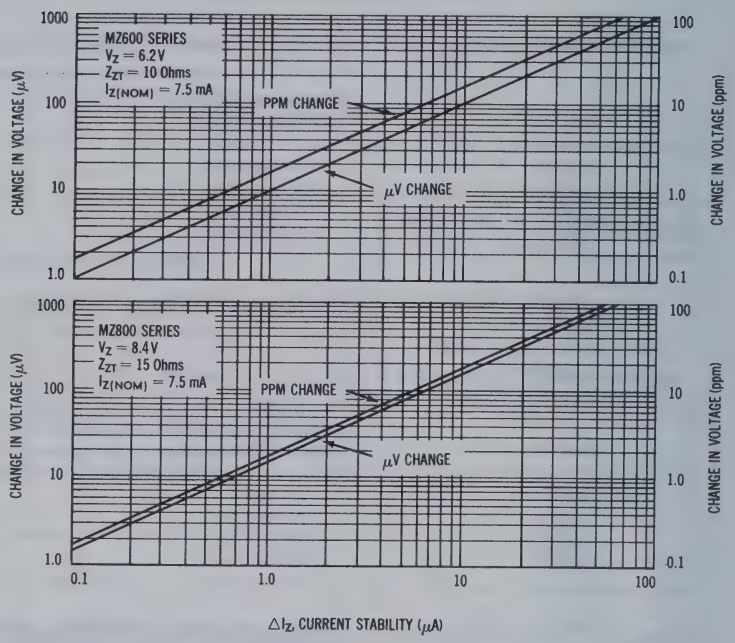
Voltage tolerance less than 5.0% is available upon special request.

Precision Reference Diodes capable of meeting special requirements for standard voltages regardless of required test current, temperature range, or test temperatures are available. Custom requirements of particular devices for specific applications are also available.

VOLTAGE-CURRENT STABILITY CHARACTERISTICS

For verification of time stability, and for repeatable operation, I_{ZT} should be maintained with a tolerance of ±0.1 μA. Figure 1 will assist in design where the supply current stability cannot be maintained to better than 0.2 μA deviation.

FIGURE 1 – MAXIMUM VOLTAGE CHANGE, IN μV AND PPM, DUE TO CURRENT SUPPLY STABILITY



VOLTAGE-TEMPERATURE CHARACTERISTICS

CHOICE OF OPERATING TEMPERATURE

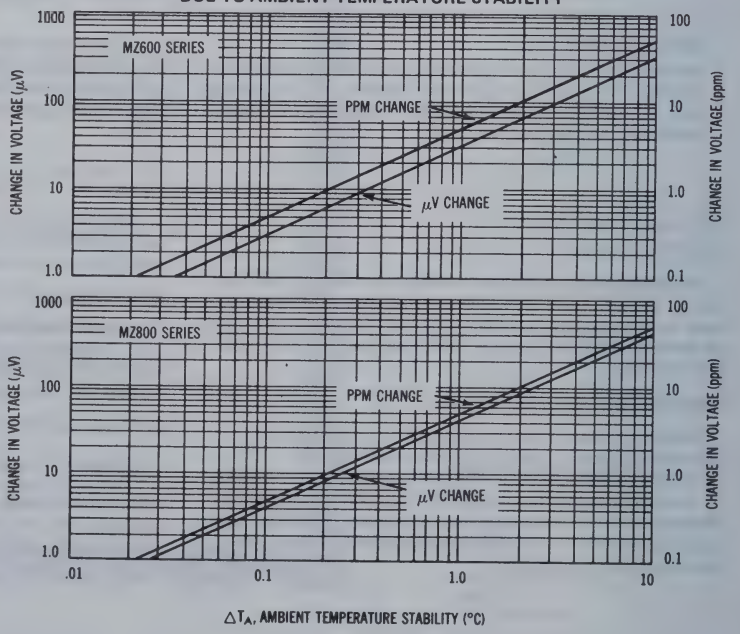
The stability certification is performed at 65°C ± 0.02°C. The operating temperature can be selected within the operating temperature range. If the desired temperature is not 65°C, the precise voltage of the device will be different but the certified stability will still be observed.

VOLTAGE TEMPERATURE STABILITY

For verification of time stability and/or repeatable operation, the ambient temperature should be controlled to ±0.1°C.

Figure 2 will assist in designs where ambient temperature cannot be controlled to better than 0.2°C deviation.

FIGURE 2 – TYPICAL VOLTAGE CHANGE, IN μV AND PPM, DUE TO AMBIENT TEMPERATURE STABILITY



MZ821,A
MZ823,A
MZ825,A
MZ827,A

6.2 VOLTS ± 5%

MZ935,A,B thru MZ938,A,B

9.0 VOLTS ± 5%

MZ941,A,B thru MZ944,A,B

11.7 VOLTS ± 5%

MZ3154,A thru MZ3156,A

8.4 VOLTS ± 5%

Designers Data Sheet

RADIATION HARDENED TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. Ramrod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Specified Radiation Effects
- Low Dynamic Impedance
- Choice of Temperature Ranges
- "Box Method" Specifications Guarantee Maximum Voltage Deviation
- Choice of Four Voltages

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

RADIATION HARDENED TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 400 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

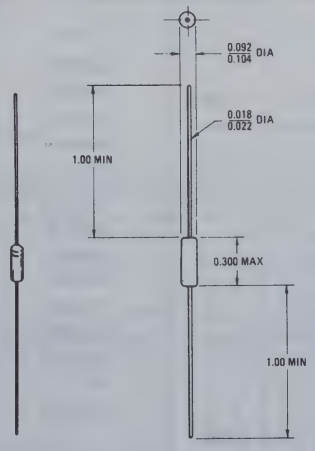
DIMENSIONS: See outline drawing

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any



All JEDEC dimensions and notes apply

CASE 51
DO-7

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Reference Voltage at Test Current	Motorola Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Air Test Temperatures °C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} Ohms (Note 3)
V_Z = 6.2 V ± 5% @ I_{ZT} = 7.5 mA	MZ821	0.096	−55, 0, +25, +75, +100	0.01	15
	MZ823	0.048		0.005	
	MZ825	0.019		0.002	
	MZ827	0.009		0.001	
	MZ821A	0.096		0.01	10
	MZ823A	0.048		0.005	
	MZ825A	0.019		0.002	
	MZ827A	0.009		0.001	
V_Z = 9.0 V ± 5% @ I_{ZT} = 7.5 mA	MZ935	0.067	0, +25, +75	0.01	20
	MZ936	0.033		0.005	
	MZ937	0.013		0.002	
	MZ938	0.006		0.001	
	MZ935A	0.139	−55, 0, +25, +75, +100	0.01	20
	MZ936A	0.069		0.005	
	MZ937A	0.027		0.002	
	MZ938A	0.013		0.001	
	MZ935B	0.184	−55, 0, +25, +75, +100, +150	0.01	20
	MZ936B	0.092		0.005	
	MZ937B	0.037		0.002	
	MZ938B	0.018		0.001	
V_Z = 11.7 V ± 5% @ I_{ZT} = 7.5 mA	MZ941	0.088	0, +25, +75	0.01	30
	MZ942	0.044		0.005	
	MZ943	0.018		0.002	
	MZ944	0.009		0.001	
	MZ941A	0.181	−55, 0, +25, +75, +100	0.01	30
	MZ942A	0.090		0.005	
	MZ943A	0.036		0.002	
	MZ944A	0.018		0.001	
	MZ941B	0.239	−55, 0, +25, +75, +150	0.01	30
	MZ942B	0.120		0.005	
	MZ943B	0.047		0.002	
	MZ944B	0.024		0.001	
	MZ945B	0.012		0.0005	
	MZ946B	0.005		0.0002	
V_Z = 8.4 V ± 5% @ I_{ZT} = 10 mA	MZ3154	0.130	−55, 0, +25 +75, +100	0.01	15
	MZ3155	0.065		0.005	
	MZ3156	0.026		0.002	
	MZ3154A	0.172	−55, 0, +25, +75, +100, +150	0.01	15
	MZ3155A	0.086		0.005	
	MZ3156A	0.034		0.002	

EFFECTS OF NEUTRON DOSAGE

FIGURE 1 – EFFECT OF NEUTRON DOSAGE ON REFERENCE VOLTAGE

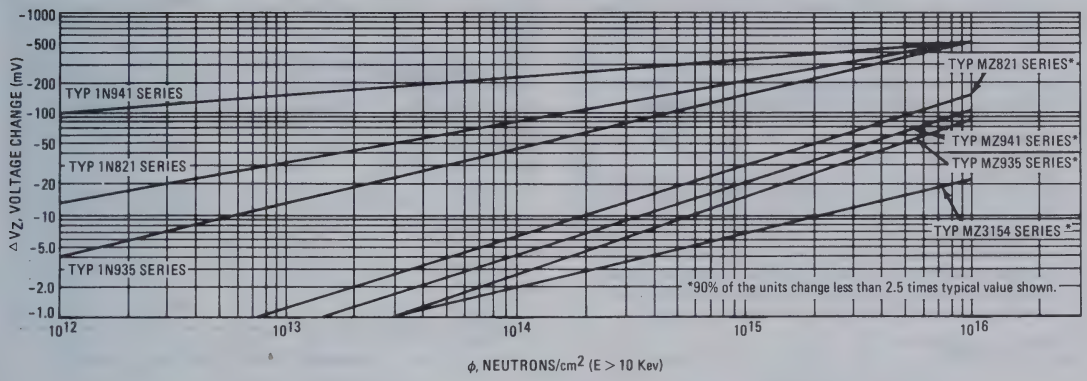
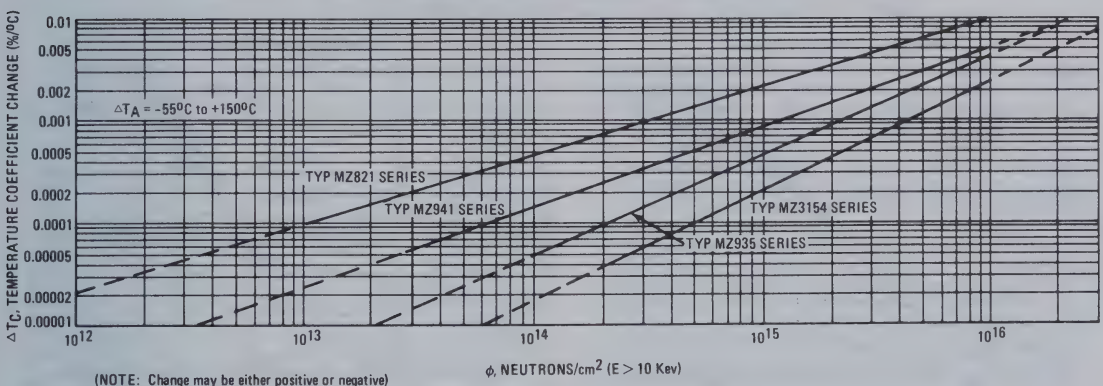


FIGURE 2 – TYPICAL EFFECT OF NEUTRON DOSAGE ON TEMPERATURE COEFFICIENT



(NOTE: Change may be either positive or negative)

FIGURE 3 – EFFECT OF NEUTRON DOSAGE ON IMPEDANCE

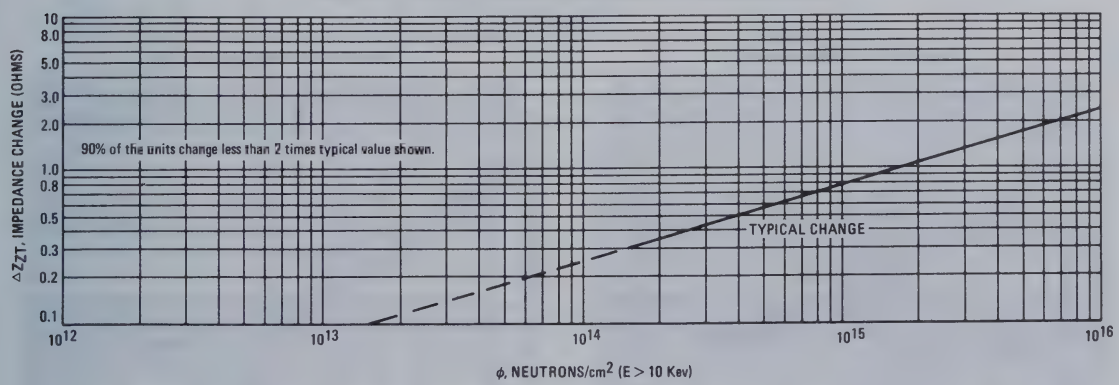
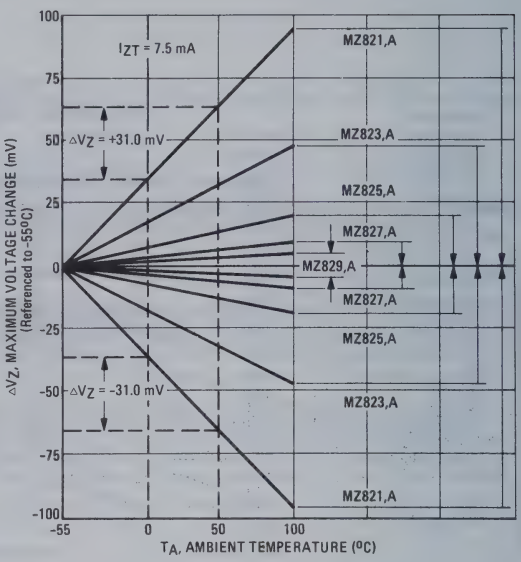


FIGURE 4
MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE
(with I_{ZT} = 7.5 mA ± 0.01 mA)

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +31 mV or −31 mV for MZ821 or MZ821A, as illustrated by the dashed lines in Figure 4. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N821,A, 1N823,A, 1N825,A, 1N827,A, 1N829,A.
The maximum voltage change, $\triangle V_Z$, in Figures 5 and 6 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding $\triangle V_Z$ in Figure 5 or 6 to the $\triangle V_Z$ in Figure 4 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 5 or 6 on Figure 4.



ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE
(At Specified Temperatures) (See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

FIGURE 5 – MZ821 SERIES

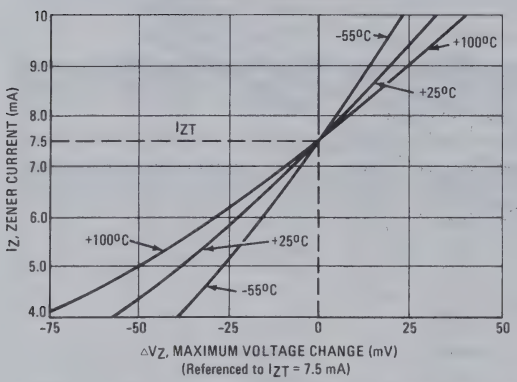
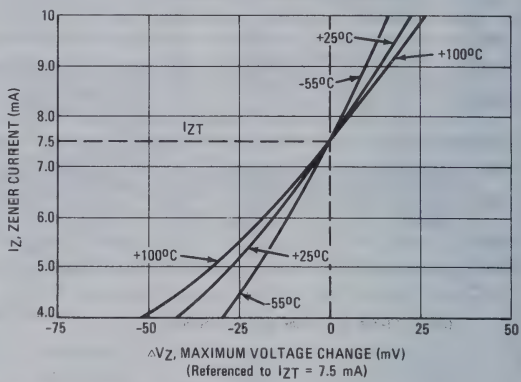


FIGURE 6 – MZ821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

FIGURE 7 – MZ821 SERIES

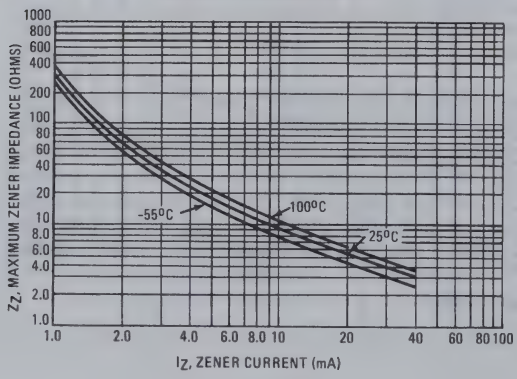
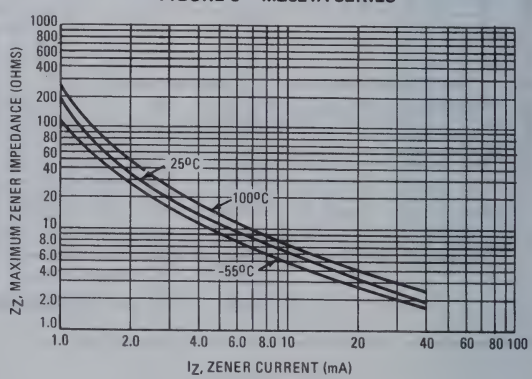


FIGURE 8 – MZ821A SERIES



MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(With I_{ZT} = 7.5 mA ± 0.01 mA)

FIGURE 9 – MZ935 thru MZ939

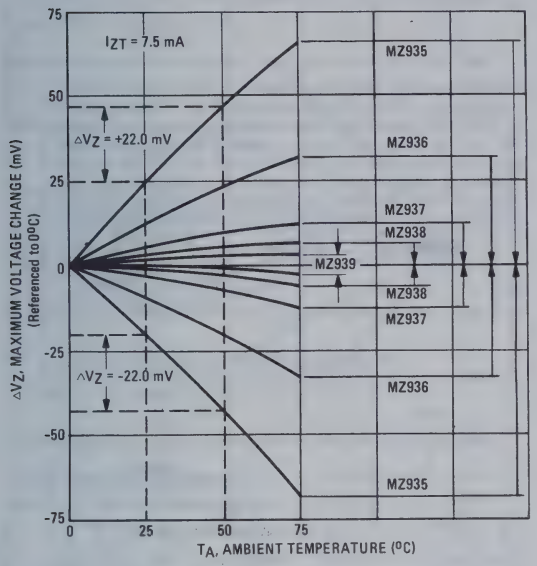


FIGURE 10 – MZ935A thru MZ939A

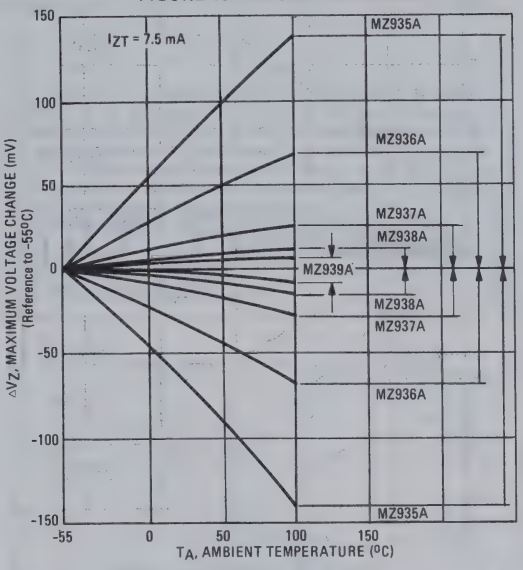
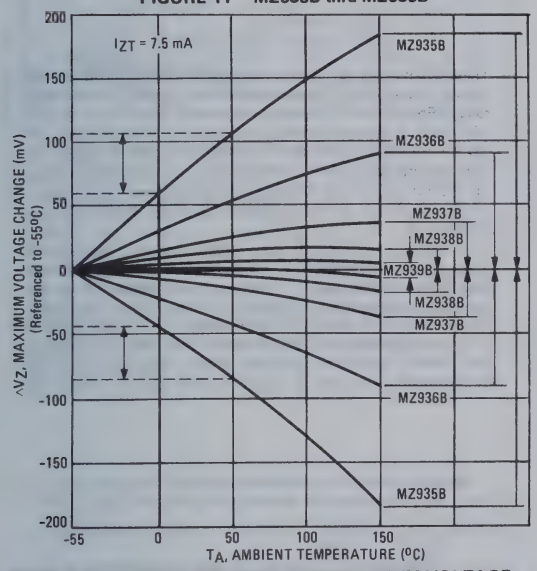


FIGURE 11 – MZ935B thru MZ939B



These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +22 mV or -22 mV for MZ935, as illustrated by the dashed lines in Figure 9. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N935,A,B thru 1N939,A,B.

The maximum voltage change, ΔV_Z, in Figure 12 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 12 to the ΔV_Z in Figure 9, 10, or 11 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 12 on Figure 9, 10, or 11.

FIGURE 12 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures) (See Note 5)

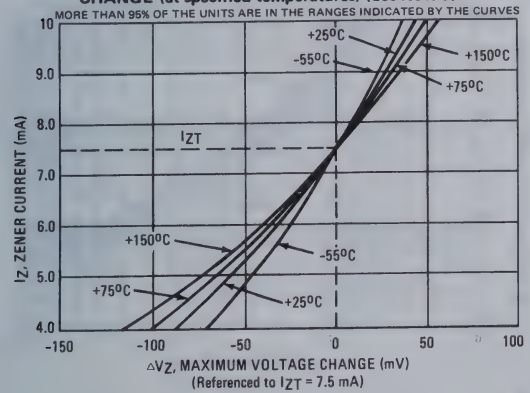
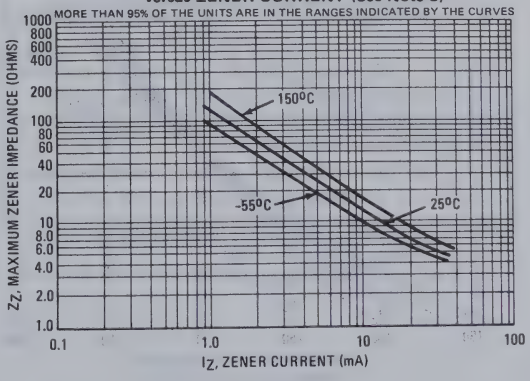


FIGURE 13 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ± 0.01 mA)

FIGURE 14 – MZ941 thru MZ946

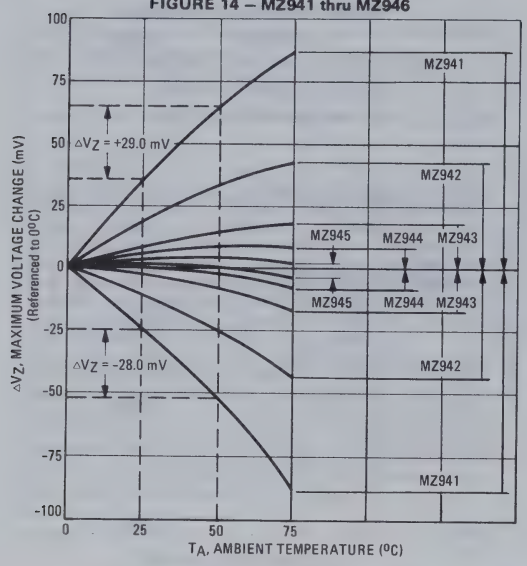


FIGURE 15 – MZ941A thru MZ946A

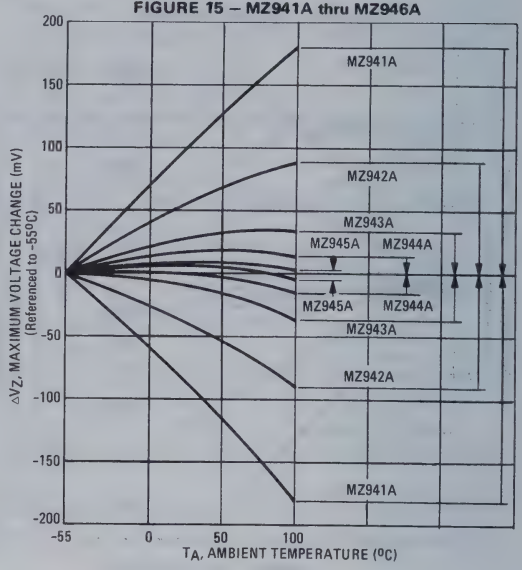
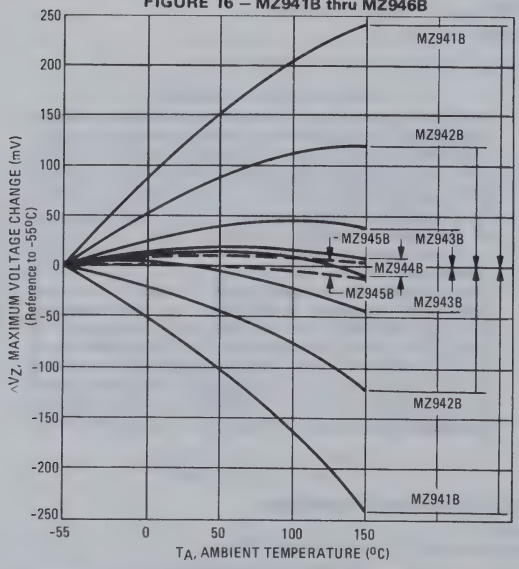


FIGURE 16 – MZ941B thru MZ946B



These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +29 mV or – 28 mV for MZ941, as illustrated by the dashed lines in Figure 14. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N941,A,B thru 1N946,A,B.

The maximum voltage change, ΔV_Z, in Figure 17 is due entirely to the impedance of the device. If both temperature and I_{ZT} are vaired, then the total voltage change may be obtained by adding ΔV_Z in Figure 17 to the ΔV_Z in Figure 14, 15, or 16 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 17 on Figure 14, 15, or 16.

FIGURE 17– ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures) (See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

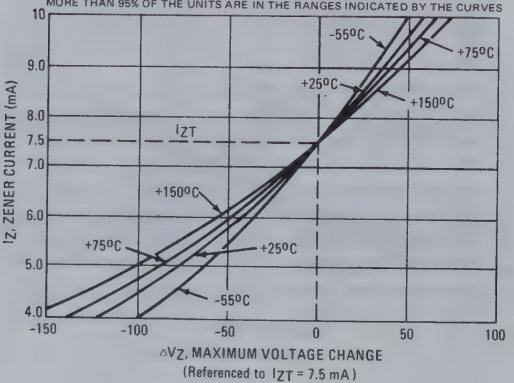
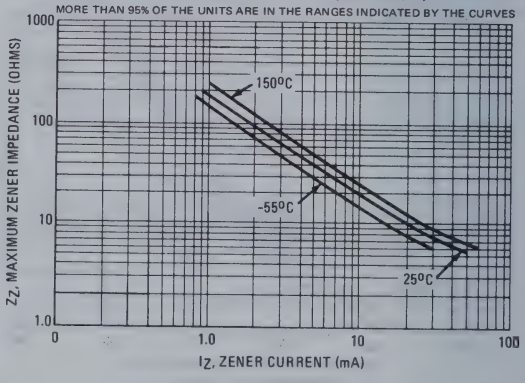


FIGURE 18 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 1.0 mA ± 0.01 mA)

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +42 mV or −42 mV for MZ3154, as illustrated by the dashed lines in Figure 19. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N3154,A thru 1N3157,A.

The maximum voltage change, $\triangle V_Z$, in Figure 21 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding $\triangle V_Z$ in Figure 21 to the $\triangle V_Z$ in Figure 19 or 20 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 21 on Figure 19 or 20.

FIGURE 19 – MZ3154 thru MZ3157

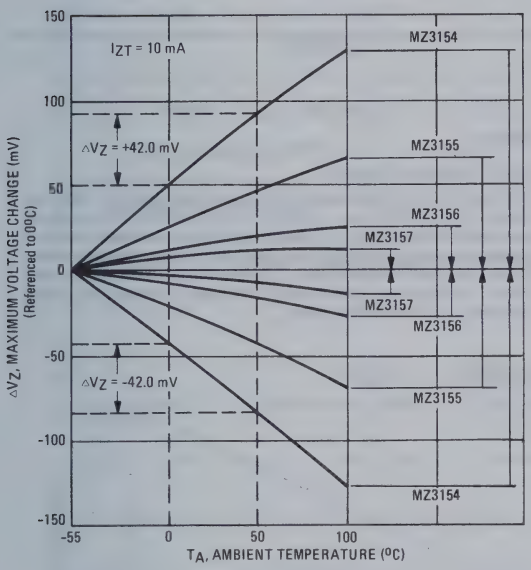


FIGURE 20 – MZ3154A thru MZ3157A

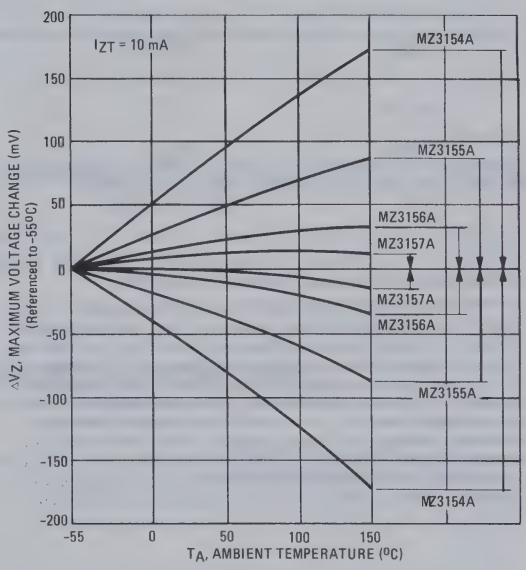


FIGURE 21 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures) (See Note 5)

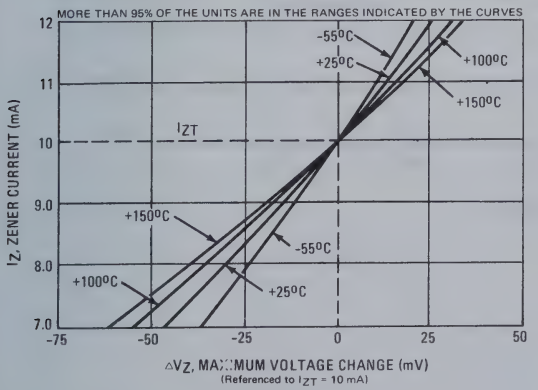
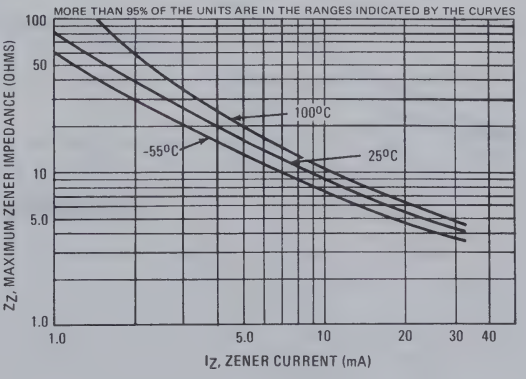


FIGURE 22 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)



RADIATION EFFECTS

Standard Zener Diodes are inherently radiation resistant because of high doping levels. This is not the case in Temperature Compensated Zener Reference Diodes because standard diffused, forward-biased, P-N junctions having negative temperature coefficients are utilized to compensate for the positive temperature coefficient of the zener die. Normally, the characteristic of the foward-biased P-N junction changes significantly with fast neutron dosage and makes the composite device sensitive to radiation. Motorola utilizes specially processed P-N junctions to provide devices capable of meeting the information shown in Figures 1, 2 and 3.

The radiation effects curves were generated based on data obtained by irradiating devices in a Triga Reactor. Note: 3 neutron/cm^2 (Triga Reactor) = 1 neutron/cm^2 (1Mev equivalent.)

NOTE 1:

The Motorola listed types have electrical specifications identical to the 1N . . . counterpart, i.e., MZ821 is identical to 1N821.

NOTE 2:

Voltage Variation ($\triangle V_Z$) and Temperature Coefficient

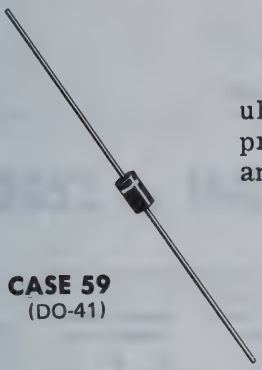
All reference diodes are characterized by the "box method." This guarantees a maximum voltage variation ($\triangle V_Z$) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicated voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of the zener impedance with zener current for each series are given. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

MZ1000-1 thru MZ1000-37 (SILICON)



CASE 59
(DO-41)

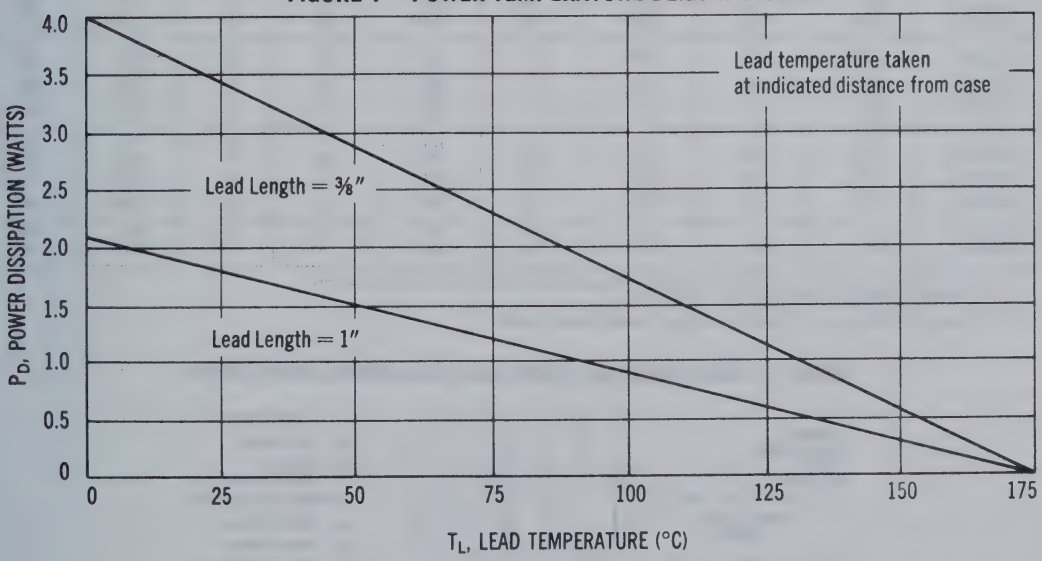
Miniature plastic encapsulated zener diodes for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C Derate above 50°C	1.5 8.33	Watt mW/°C
Lead Temperature*	-65 to +175	°C

*Maximum lead temperature for 10 seconds at 1/16'' from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MZ1000-1 thru MZ1000-37 (continued)

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).

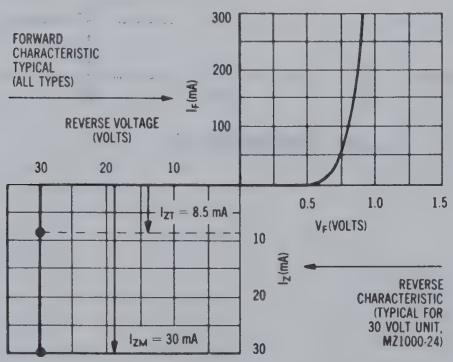
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Type No.	Zener Voltage V_Z @ I_{ZT} Volts*			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current I_R @ V_R		Temperature Coefficient %/°C
	Min	Nom	Max				μA Max	Volts	
MZ1000-1	2.97	3.3	3.63	76	15	276	150	1	-.070
MZ1000-2	3.24	3.6	3.96	69	15	252	150	1	-.065
MZ1000-3	3.51	3.9	4.29	64	13.5	234	75	1	-.060
MZ1000-4	3.87	4.3	4.73	58	13.5	217	20	1	-.050
MZ1000-5	4.23	4.7	5.17	53	12	193	20	1	-.043
MZ1000-6	4.59	5.1	5.61	49	10.5	178	20	1	±.030
MZ1000-7	5.04	5.6	6.16	45	7.5	162	20	2	±.028
MZ1000-8	5.58	6.2	6.82	41	3	146	20	3	+.045
MZ1000-9	6.12	6.8	7.48	37	5.25	133	20	4	.050
MZ1000-10	6.75	7.5	8.25	34	6	121	20	5	.058
MZ1000-11	7.38	8.2	9.02	31	6.75	110	20	5.9	.062
MZ1000-12	8.19	9.1	10.01	28	7.5	100	20	6.6	.068
MZ1000-13	9	10	11	25	10.5	91	20	7.2	.075
MZ1000-14	9.9	11	12.1	23	12	83	10	8.0	.076
MZ1000-15	10.8	12	13.2	21	13.5	76	10	8.6	.077
MZ1000-16	11.7	13	14.3	19	15	69	10	9.4	.079
MZ1000-17	13.5	15	16.5	17	21	61	10	10.8	.082
MZ1000-18	14.4	16	17.6	15.5	24	57	10	11.5	.083
MZ1000-19	16.2	18	19.8	14	30	50	10	13.0	.085
MZ1000-20	18	20	22	12.5	33	45	10	14.4	.086
MZ1000-21	19.8	22	24.2	11.5	34.5	41	10	15.8	.087
MZ1000-22	21.6	24	26.4	10.5	37.5	38	10	17.3	.088
MZ1000-23	24.3	27	29.7	9.5	52.5	34	10	19.4	.090
MZ1000-24	27	30	33	8.5	60	30	10	21.6	.091
MZ1000-25	29.7	33	36.3	7.5	67.5	27	10	23.8	.092
MZ1000-26	32.4	36	39.6	7	75	25	10	25.9	.093
MZ1000-27	35.1	39	42.9	6.5	90	23	10	28.1	.094
MZ1000-28	38.7	43	47.3	6	105	22	10	31.0	.095
MZ1000-29	42.3	47	51.7	5.5	120	19	10	33.8	.095
MZ1000-30	45.9	51	56.1	5	142.5	18	10	36.7	.096
MZ1000-31	50.4	56	61.6	4.5	165	16	10	40.3	.096
MZ1000-32	55.8	62	68.2	4	177.5	14	10	44.6	.097
MZ1000-33	61.2	68	74.8	3.7	225	13	10	49.0	.097
MZ1000-34	67.5	75	82.5	3.3	262.5	12	10	54.0	.098
MZ1000-35	73.8	82	90.2	3	300	11	10	59.0	.098
MZ1000-36	81.9	91	100.1	2.8	375	10	10	65.5	.099
MZ1000-37	90	100	110	2.5	525	9	10	72.0	.100

*1. Nominal voltages other than those stated above, matched sets, and tighter voltage tolerances are available, 1N4728 thru 1N4764 series (1M3.3ZS10 thru 1M100ZS10).

2. Voltages to 200 volts are available in other package configurations on request.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ4614 thru MZ4627 (SILICON)

For Specifications, See 1N4099 Data, Volume 1.

M4L3052 thru M4L3056 (SILICON)

For Specifications, See 1N5158 Data.

ENGINEERING ASSOCIATES
JAN 23 1974